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A SAFETY MANUAL FOR

PROPANE BUS SYSTEMS

Prepared by:

R.F. Webb Corporation Ltd.
1011/5 Prince of Wales Drive,
Ottawa, Ontario K2C 3K1

Telephone: 613-224-8460

For:

Ottawa-Carleton Regional
Transit Commission,
1500 St. Laurent Blvd.
Ottawa, Ont.

and

Transportation Development
Centre (TDC),
1000 Sherbrooke St. W.,
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17 Abstract

The report is a reference source and training aid for the safe operation and maintenance of propane buses.

It discusses the properties of automotive grade propane, the means available to convert conventional diesel buses to propane-engined units, and the regulations, practices and equipment necessary to store the fuel at the garage, refuel buses, convert and test buses, garage and repair the vehicles and operate them in revenue service. Particular attention is given to the prevention of fires and to methods for containing the risk and damage from fires, should they occur.

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17 Resumé

Ce rapport se présente comme un ouvrage de documentation, et une aide à la formation, en matière de conduite et d'entretien sécuritaires des autobus au propane.

Il traite des propriétés du propane pour la propulsion des véhicules, des moyens pratiques pour convertir les autobus diesel courants en autobus au propane et des règlements applicables au stockage du propane, au ravitaillement des autobus, à leur conversion et leurs essais routiers, à leur entretien et enfin à leur mise en service payant, ainsi que des méthodes et équipements connexes à mettre en oeuvre. Ce document s'attache en particulier aux consignes de sécurité, notamment la prévention des incendies et la maîtrise de ceux-ci dans le but de réduire au minimum les dangers et les dégâts qu'ils peuvent entraîner.

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SUMMARY

The large increase in the price of crude oil in the past decade, and concerns about the price, quality and long-term supply of diesel fuel have prompted many fleet operators to switch to propane. Fleet conversions to propane are facilitated by conversion grants available from the federal government and reduced road fuel tax rates on propane in certain provinces and by other government programs aimed at encouraging the use of propane and other alternatives to gasoline or diesel fuel.

The Ottawa-Carleton Regional Transit Commission (OC Transpo) is conducting a two-year demonstration of the use of propane in city buses under a program supported in part by the Ontario government and the government of Canada. The basic properties, storage and safety requirements for a propane operation differ substantially from those for diesel fuel. Accordingly, OC Transpo decided to produce a manual on propane safety which would be a reference work drawing upon the extensive, but somewhat scattered literature, and the experience of other fleets on propane.

The Transportation Development Centre of Transport Canada (TDC) has a responsibility for managing a number of programs on the use of alternative fuels in the transport area and was able to provide and manage a contract to OC Transpo to develop a safety manual designed specifically for a propane-fuelled city bus fleet.

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1. AN INTRODUCTION TO PROPANE AS A MOTOR FUEL

1.1 Propane in Canada

Canada must import a significant proportion of the crude oil it needs for the production of gasoline, diesel and other transport fuels, while at the same time another hydrocarbon fuel - propane - is available in such abundance that about half of the nation's daily production of 19-20 million litres of propane is exported. In addition to its use as a heating fuel, propane has been in use as long as gasoline and diesel as a fuel for automobiles, trucks and in some cases, buses. Because of its clean burning characteristics, propane is also favoured as a fuel for fork-lift trucks and other engine applications inside buildings or in crowded places. Supply and cost considerations and low levels of pollution from propane engines, together with new developments on the engine side, now make it feasible to use propane as a bus fuel at the Ottawa-Carleton Regional Transit Commission (OC Transpo) with anticipated benefits similar to those already achieved by bus properties such as the Vienna Transit Authority in Austria.

While propane is a hydrocarbon fuel, it is a gas and very different in its behaviour and properties from diesel fuel. Its efficient and safe use in the OC Transpo system requires an understanding of the way the new fuel should be handled and changes needed in the buses and garage to maintain the excellent accident and service record of OC Transpo.

1.2 The Nature of Propane Motor Fuel

80% of Canada's propane is obtained by stripping it from natural gas, the remainder being recovered from the gases produced in the refining of crude oil to conventional petroleum fuels. The products recovered are a mixture of gases termed 'LPG' (liquefied petroleum gas) from which a purified grade of automotive propane (the HD-5 grade) is produced according to a national specification similar to the specification placed on gasoline. The specification (CAN2-3.14-M78, see Table 1) sets minimum levels for propane content (90% by volume) and the maximum levels of other combustible components which lower the octane number of the fuel and therefore the anti-knock characteristics in spark ignition engines. The specification also limits the maximum sulphur content of the fuel, since sulphur accelerates engine wear. Because propane is odourless, evil-smelling sulphur-containing compounds (called 'mercaptans') are added in small amounts so that leaks are detectable even down to levels of propane in the air of one fifth that needed to support combustion. The minimum motor octane number of 95 in HD-5 propane is particularly favourable for truck and bus spark ignition engines and much higher than that set for unleaded gasoline in Canada (82 MON).

Table 1

HD-5 Automotive Grade Propane Specifications

	Minimum	Maximum
Components, liquid volume %		
Propane	90	-
Propylene	-	5.0
Butane and heavier hydrocarbons	-	2.5
Vapour pressure at 37.8°C, kPa		1435
Motor Octane Number	95	-
Sulphur (Lamp method) mg/m^3 vapour at 15°C and 101.325 kPa	-	230
Corrosion (copper strip)	-	No.1

Other important properties of automotive propane, which are listed in Table 2, are next discussed. They differ substantially from the properties of gasoline and diesel and an understanding of the basic properties of propane will be a great help in understanding how to use the fuel with safety.

Unlike most other gases (including natural gas), propane can be converted from the gas state to a gasoline-like liquid by pressure alone and can therefore be stored under pressure as a liquid in the manifolded fuel tank situated under the floor of the bus. Because of the need to store and transfer propane as a liquid under pressure, all transfer lines and storage equipment must be leak-proof and designed with safety and shut-off valves. Leaks and valve malfunctions are the major safety concerns in propane systems.

The pressure in the fuel storage tank varies with the temperature of the propane which will respond with a lag period to changes in the prevailing atmospheric temperature. Propane liquid has an exceptionally high coefficient of expansion. When a propane storage tank is exposed to the hot sun, or when a bus is brought from outside into a heated garage on a cold winter's day, the liquid propane will expand. Room for this expansion must be left in the vehicle propane storage tank. This accounts for the legal requirement that propane storage tanks not be filled beyond the 80% liquid level and that filler valves and propane storage tanks normally be designed to prevent filling beyond the 80% level. Even with this precaution, every tank must also be fitted with a pressure relief valve adjusted to hold the propane in the liquid state, but to vent propane, should the pressure in the tank reach a higher level (1750 kPa, 250 psig for tanks mounted external to a vehicle as in the bus, or 2150 kPa, 312.5 psig when the tank is inside an enclosed compartment in the vehicle).

Since the pressure within a propane tank varies with temperature, under normal conditions the pressure of the vapour above the liquid in the fuel tank is sufficient to pump the liquid phase out of the cylinder when required by the engine. At $-42^{\circ}C$, however, the pressure above liquid propane reaches the level of the atmosphere and the pumping action is not available. Since propane engines, unlike gasoline or diesel engines, do not have fuel pumps and rely upon the self-pumping action of propane vapour, it is essential to maintain the propane cylinder at somewhat above the $-40^{\circ}C$ level for cold start and running. Tank or in-vehicle heaters and/or inside garaging are needed for the most severe winters unless a specially formulated cold weather grade of propane is available.

When the engine is running, the propane liquid is converted to vapour in the convertor and the pressure reduced. The propane vapour is mixed with air in the carburetor and a totally gaseous mixture sent to the cylinders. This differs from gasoline engines where liquid fuel is injected into the carburetor and the cylinders receive a mixture of air,

Table 2

Important Properties of Automotive Propane

Compared to Gasoline and Diesel Fuel

Properties	Propane	Gasoline	Diesel Fuel
Normal state at atmosphere pressure and 15°C	gas	liquid	liquid
State under pressure at 15°C (1700 kPa or 200 psi)	liquid	liquid	liquid
Density of vapour relative to air (=1)	1.52	3.5	N/A
Density of liquid relative to water (=1)	0.51	0.73	0.83
Ratio of volume of propane vapour to liquid	265 to 270*	-	-
Boiling point °C	-42	30 to 200	150 to 380
Thermal expansion of liquid from 0°C to 40°C	13%	small	small
Combustion Characteristics			
Flammability range volume of fuel, % in air	2.3 to 9.5*	1.3 to 6%	0.7 to 5.0
Ignition temperature in air, °C	495 to 550*	455	400 to 500
Fuel consumption (litres per km) relative to diesel bus operation	1.6 to 1.7	1.33	1.0

* Depends somewhat on composition of commercial grades of automotive propane

gasoline vapour and droplets, and diesel engines where liquid fuel is injected directly into the compressed air contained in the cylinders.

The advantages of using a premixed propane-air mixture include the absence of dissolved solids in the fuel (which build up with gasoline and diesel engines), and the even distribution of the combustion mixture to all cylinders.

The pressure drop involved in conversion of liquid propane to propane vapour is accompanied by a large increase in volume and a sharp temperature drop. The expanded vapour can therefore be much colder than the liquid, but rapid vaporization also cools the liquid fuel lines and the storage tank. In the normal engine running process the liquid propane withdrawn from the storage tank is heated in the vapourizer (essentially a heat exchanger) by using the engine coolant water which is circulated through the vapourizer. Where propane leaks occur in the bulk storage system at the garage or on-board, the vapour is usually made visible by its cooling effect on the air so that a cloud of water vapour surrounds the cold escaping gas, or ice frost build-up is noted close to the site of the leak.

The cooling effect of expanding vapourizing propane must be guarded against, since contact with the liquid at any time may cause frost burns. Protective gloves are essential in operations, such as fuelling where contact with the liquid is likely. Another aspect of the vapourization of propane to be considered is the very large increase in the volume involved: the vapour occupies about 270 times the volume of the liquid, which explains the pressure build-up that is possible in tanks and the need for pressure- rated transfer lines and valves.

Propane in the gaseous form is heavier than air and in considering the safety aspects of fuelling and inevitable venting of propane vapours, the flammable vapour should be visualized as similar to the white clouds of 'dry ice' (carbon dioxide) used on stage to give cloud effects, or to the oily fumes that are sometimes seen when fuelling at the gasoline pump in the summer. Like these dense vapours, propane can collect in gulleys, pits and drains, but is readily dispersed by wind and ventilation. When propane is released into the air and is not prevented from mixing with it, the mixture rapidly passes from a region where it is too rich to support combustion (more than 10% by volume of propane in air) through the combustion range (2.3-9.5% propane in air for commercial propane) to a region (below about 2.3% propane) where the mixture is too lean to burn.

1.3 The Propane Engine

There are many ways in which propane can be used as an engine fuel, ranging from the use of propane as the sole fuel in a spark ignition engine to other so-called 'dual fuel' modes in which propane partly replaces diesel fuel in a modified compression-ignition (diesel)

engine or gasoline in a spark ignition engine.

The new engines for OC Transpo buses are equipped with a spark ignition system specifically manufactured to operate in heavy duty transit service. This engine and fuel system is more robust than that found in large gasoline engines and has other features which distinguish it from the conventional spark ignition system (see Figure 1):

- In contrast to the simple conventional fuel tank for gasoline or diesel, propane is stored in a PRESSURIZED PROPANE FUEL TANK fitted with built-in safety, filling and excess flow valves.

- Because propane vapour and liquid are stored under pressure in the fuel tank, a fuel pump is not required: even down to -30°C the vapour pressure in the fuel tank is sufficient to deliver fuel to the engine on demand.

- The pressure in the fuel system requires the installation of HIGH PRESSURE PROPANE HOSE to connect the fuel tank to the engine through the fuel lock, filter and vapourizer.

- The safety of the system is assured by the incorporation of a fuel lock valve. This is incorporated with the fuel filter in the FUEL LOCK-FILTER ASSEMBLY.

- Fuel delivered beyond the fuel lock-filter on demand is converted into propane vapour at the VAPOURIZER-REGULATOR which is heated by the engine coolant water system to overcome the temperature loss and to prevent frosting up when propane vapourizes.

- Propane in the vapour state is mixed with air in the CARBURETOR: the absence of liquid simplifies the construction and maintenance of the carburetor compared to those used with gasoline; the propane carburetor is essentially a gas mixer which delivers the propane-air mixtures free of liquid evenly to all cylinders.

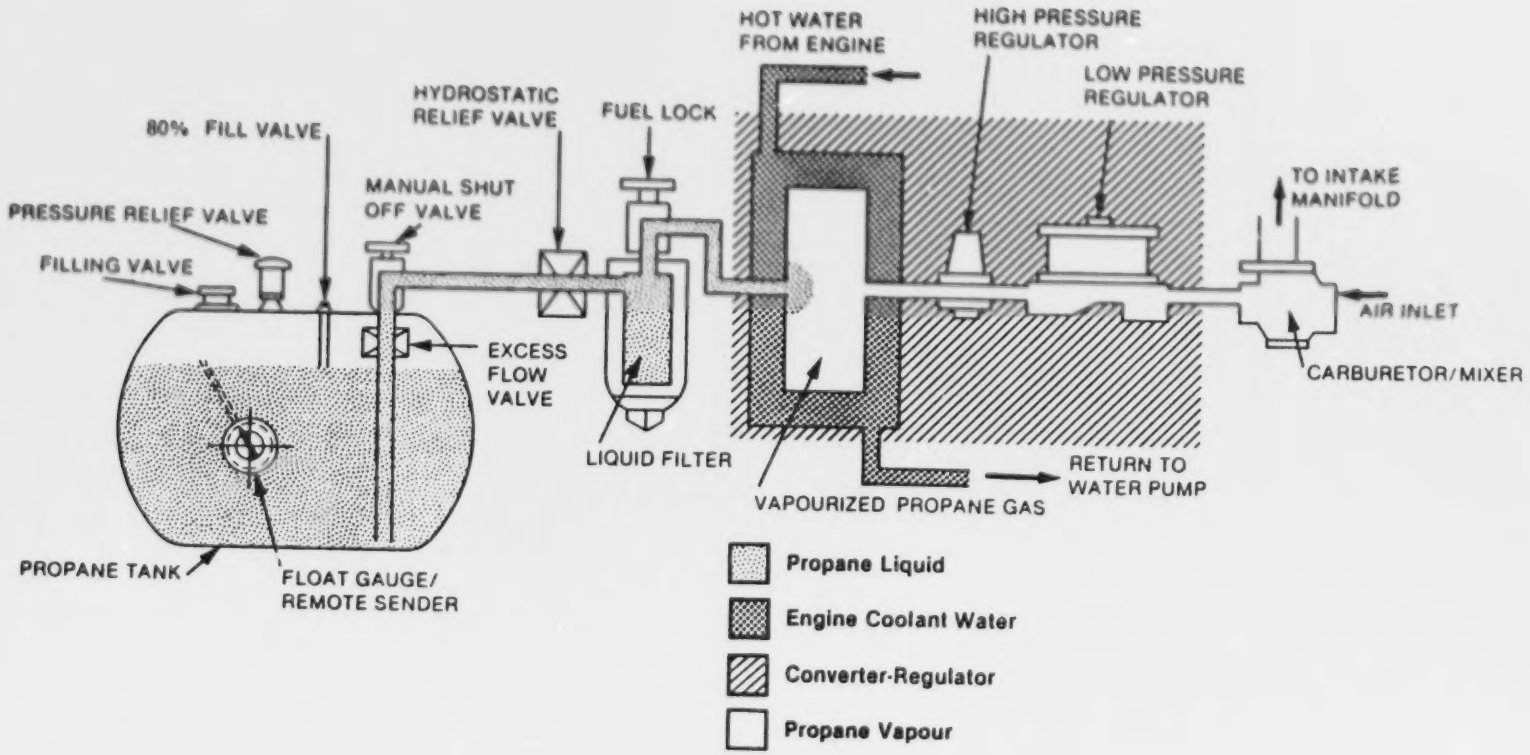
- The propane engine is tailored to the high octane value of propane fuel and operates at a compression ratio (10.9:1) intermediate between that of a conventional gasoline engine (8.5-9:1) and that of a conventional diesel engine (18-22:1).

- The combustion temperature reached by combusted propane-air mixture in the cylinders is somewhat higher than that of gasoline or diesel and thermal shielding of the exhaust pipe is incorporated in the system design.

- Taken as a whole, the on-vehicle propane storage and engine delivery system is no more complex than that used in conventional gasoline or diesel-powered units. The absence of moving parts for fuel pumping or fuel injection leads to a reduced level of

Figure 1

The Propane Fuel System in the Bus



equipment failures with the gaseous fuel system which improves the reliability of the fuel system and may improve its safety performance. The simple nature of the equipment needed for propane may be even more important in the future when pollution control accessories will be required on conventional buses to reduce the levels of unburnt hydrocarbons, carbon monoxide, nitrogen oxides and particulates (black smoke) now emitted with the exhaust gases of diesel-fuelled buses. Propane engines are renowned for the low levels of smoke and other pollutants they produce, which explains their broad use in fork-lift trucks and other equipment used in factory and restricted environments.

1.4 Areas for Special Attention

As with all combustible materials, vigilance in the maintenance of high standards of fuel equipment installation, handling and inspection is the key to safety at the garage and on the road.

Inspection of the safety record of propane buses in regular service shows that the propane vehicles are at least as safe as their diesel and gasoline equivalents. Where problems have been reported with propane, they lie principally in the lack of familiarity or inadequate training of personnel responsible for the installation or inspection of the fuel storage facilities and human errors which may arise when refuelling is undertaken without prior familiarization of the staff with the properties of the gaseous fuel.

Safety is a system-wide concern and accidents are normally the outcome not of one single event, but of a chain of unlikely circumstances which come together at the wrong time from different corners of the system. Vigilance and training are paramount. With propane particular attention should be given to:

- Recognition that propane/air mixtures in the flammable range can be ignited by cigarettes, open flames, or sparks from faulty electrical equipment (however, the flammability range is narrow and the gas dissipates rapidly).

- Recognition that since propane is stored and piped under pressure, leaks and line ruptures can spread the vapours rapidly over the ground, but that leaks and ruptures can be avoided when properly selected, shielded and inspected hardware is used.

- Recognition that propane gas, although deliberately given an odour for detection purposes, is invisible and that tanks and lines must be vented before being exposed to welding operations or used in the vicinity of electrical equipment that is not spark-proof.

- The installation in the repair shop of adequate ventilation, and

training of staff in the way to vent and dilute propane with air before work is undertaken on the maintenance or repair of propane lines, valves and tanks.

- Filling of tanks in vehicles beyond 80% of tank capacity must be avoided to prevent venting of propane should the tank temperature rise.

- Collision experience in over twenty years of bus service and extensive crash tests have shown that the self-sealing (valved) thick wall steel pressurized propane tanks used in vehicles are less likely to cause or sustain a fire than conventional gasoline and diesel tanks. In fact, the U.S. Interstate Commerce Commission has stated that LPG is a safer fuel than either gasoline or diesel.

1.5 A Propane Fleet Strategy

The introduction of a number of propane buses into regular urban service is a major change in fleet operations compared to the previous experience where service trucks and automobiles were converted from a gasoline option to propane. This first step with small vehicles is a useful introduction to propane safety and handling procedures but the switch to large vehicle, large volume use requires a new strategy for operation.

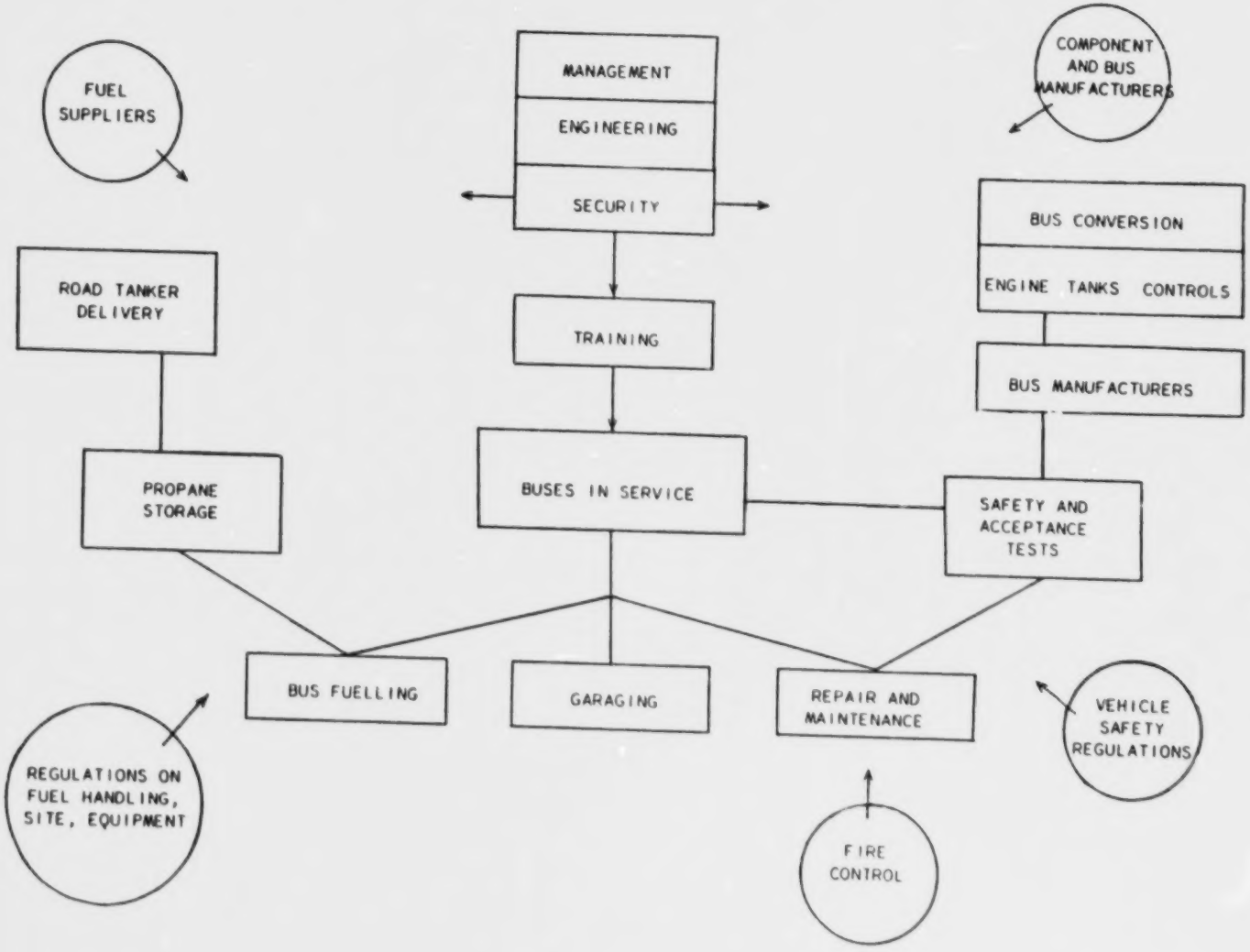
The most visible part of the changes involved in the switch to propane buses, illustrated in Figure 2, is the hardware component: the buses with their new engines and fuel tanks, the new propane storage area, the new fuelling stations at the garage and other changes needed in the garage and repair shop to signal the presence of propane and to avoid unsafe operations. Just as important as the buses and other hardware is the attitude taken towards propane by all persons exposed to its handling and their willingness to apply in detail the large cumulative experience with propane vehicle fuel which has been gained in thousands of garages world-wide and which is embodied in the extensive set of regulations and codes and the training programs which form the second major component of the propane bus system.

We accept the fact that all buses must be routinely checked and tested and that shortcomings in safety and performance must be promptly reported and acted upon, even when the well-tried diesel system is used.

With the propane system it is no less important that routine checks and tests be made of the equipment security and safety procedures and training programs and that shortcomings in these areas also be promptly reported and acted upon. The strategies for operating the propane fleet must therefore place personnel training in the forefront of the activities required and allocate the means to keep the staff informed, up-to-date and interested in the best practices and the rules,

Figure 2

Components of the Propane Bus System



as well as the hardware.

We now proceed to an examination of the major components of the propane system with particular reference to the safety issues involved.

2. THE TRANSPORTATION AND LOADING OF PROPANE

2.1 Bulk Movements of Propane

Each bus on average will require about 1000 litres of propane a week, so the volume of propane moved onto the property and the 3 day supply held in storage represent a significant volume of storage at the site. While there are over 60 years of experience in Canada in the bulk movement and storage of propane, special conditions apply to storage of the fuel in the vicinity of vehicles and within city perimeters. The experience of bus properties in Chicago and Vienna involving similar large volumes of automotive propane has been tapped for this manual. Also of great value is the summary of propane regulations published by the Canadian Gas Association entitled "Ontario Propane Storage, Handling and Utilization Code," copies of which are kept for inspection and training purposes in the Equipment Engineering Department.

The responsibility for bulk transport of propane from the production sites at the gas separation plants and refineries lies with very experienced major companies in the field and with the regulators and operators of pipelines, railway tank cars and road tankers which move the commodity into and out of bulk and local storage facilities. Like all fuels, propane is classified in the dangerous goods category for transportartion purposes, and movements are subject to the provisions of the Dangerous Goods Transportation Act and provincial regulations. Since each railway tank car on average carries 75,000 litres of propane and each large road tanker about 30,000 litres, the risk when derailments and collisions occur is significant.

For OC Transpo, the safety considerations for the bulk movement of propane lie in the movement of fuel tankers onto the garage site, the fuel transfer operation to bulk storage, the maintenance of the fuel inventory and the fuelling of each propane bus.

The selection of the site for delivery and storage, the equipment for storage and dispensing of propane fuel and the practices that must be used in the daily routine and in emergency cases are critical. All must be designed:

- to reduce the exposure of staff and the general public to safety and environmental risks

- to reduce the possibility for tanker incidents through on-site collisions, improper coupling and uncoupling of the delivery hoses and other incidents which discharge propane, or expose propane during transfer, to sparks, flames and other ignition sources

- to provide safe means for the disposal and dispersal of propane spills
- to provide protection of the propane storage area from wear, corrosion, accidents, and vandalism
- to have in place trained staff, procedures, appropriate alarms, repair and firefighting equipment
- to maintain liaison with the local fire department
- to keep current with experiences and developments in bulk propane storage and fuelling regulations, practices and equipment
- to maintain records of bulk movements onto the site and to prepare reports on all on-site incidents involving significant accidents to personnel and equipment involved in the receipt, transfer, storage and dispensing of propane.

2.2 Fuel Quality

2.2.1 The Importance of Fuel Quality

The use of propane which does not meet the minimum specification of the HD-5 standard can lead to corrosion in the engine and storage tanks and to engine damage. A quality control program should be instituted which will require analyses from the supplier and regular sampling and testing of delivered fuel.

2.2.2 Sampling and Testing

Due to the special equipment and processes required, even large fleet users will be advised to contract out the testing activity. The Fuels and Lubricants Laboratory of the National Research Council is equipped to perform the analyses under contract according to procedures described by the American Society for Testing and Materials in its annual book of ASTM standards.

The most effective point for fuel sampling by the test laboratory will be to take samples from the on-site bulk storage facilities of OC Transpo, but random sampling of tanker deliveries is an adequate substitute. The test laboratory will have the necessary supplies and connections to withdraw samples into the analytical pressure vessel. Sampling intervals of once per month will suffice, unless substantial variations in sources of supply or storage methods are encountered.

Test work must be promptly performed and reported within 72 hours in the form of a FUEL TEST REPORT submitted in 4 copies to the Equipment Division, which shall advise the purchasing manager of any variations from the HD-5 specification (or other fuel quality specification agreed

upon with the supplier). The tests shall include measurements of the key parameters that affect fuel quality and engine safety/performance/durability which are:

1. Composition of the product by hydrocarbon components.
   Test method: vapour chromatography reporting hydrocarbon components and %.
2. Vapour pressure.
   Test method: gauge pressure at 37.7°C.
3. Sulphur content.
   Test method: Lamp burn test.
4. Water content.
   Test method: colour change of cobalt bromide.
5. Residue.
   Test method: non volatiles, oil etc. measured.
6. Corrosion.
   Test method: corrosion of copper strip.
7. Specific gravity.
   Test method: hydrometer measurements.

Examples of the safety implications of fuel quality include:

- engine knock and piston damage will occur if low octane fuel is used. The octane number can be judged from the proportion of hydrocarbons other than propane in the sample.
- a substantial water content will lead to freeze-up in transfer lines and valves, thereby increasing safety hazards
- a high rate of corrosion can similarly affect the long term safety of the fuel storage systems at the garages and in the vehicle, while also increasing maintenance costs and parts replacement in the engine.

The determination of the actual level of contaminants, comparisons with specifications, and interpretation of their effect on wear, reliability and hence safety, is a complex subject but it is sufficient here to note that safety and operating costs can be improved by the maintenance of a program for the analysis and reporting of fuel quality.

2.3 Road Tanker Delivery

2.3.1 The Regulations

The most hazardous processesin the total propane system are those in which propane is transferred from one tank to another, whether it be at the point of delivery of the bulk commodity to on-site storage, or the step of refuelling buses. Utmost attention must be paid to training, compliance with the fuel transfer procedures, and the

maintenance and inspection of transfer and storage equipment. Large quantities of propane are handled at the fuel delivery to storage stage and this process must be given appropraite supervision.

Few bus properties will consume enough propane to justify the installation of a railway spur to permit deliveries of up to 120,000 litres per shipment by rail tanker. This is the principal method of delivery to the bulk terminals of large volume propane distributors. Delivery from bulk terminals to most fleets will be by road tanker which can carry up to 50,000 litres, or by bob-tails which normally carry up to 30,000 litres of propane. A 100 vehicle bus fleet, for example, could be serviced with three drop-offs per week each of 30,000 litres with on-site storage providing a buffer supply of 30,000-45,000 litres of propane.

The propane supplier, the driver and the tank truck must be licensed to transport and unload propane. The tanker and on-board fuel loading and unloading equipment will conform to Canadian Standards and provincial regulations. The key items relating to safety at the OC Transpo site are that tankers be of sufficient pressure rating and protected from corrosion; that the propane relief valve on the tanker should vent upward, while the vehicle exhaust flow should be directed away from the propane cargo tank. Many other details of tanker design are contained in Section 14 of the National Standards of Canada contained in the 1983 publication of the Canadian Gas Association "Ontario Propane Storage, Handling and Utilization Code", copies of which are kept in the OC Transpo library. The reponsibility for compliance rests with the supplier.

For OC Transpo there are three areas of safety related to the bulk transport of propane onto the site to be monitored:

1. To check that the supplier's vehicles and inspection process conform to required standards.
2. To control the movement of the tanker while on the property.
3. To ensure that safe procedures are used in transferring propane from the tanker to the on-site storage tanks.

2.3.2 Checks on Road Tankers

The supply contracts with tanker operators will require that the operators comply with all provisions of the province's regulations and that regular checks are made on all tankers which enter the bus property. The tanker owner's records of regular inspections will be available to OC Transpo management upon request. The inspections are to include checks of the fuel cargo tanks, the internal valves and controls in the tanks and pump, lines and hoses used for transferring propane. General checks of the vehicle are also to be included in the reported inspections. A check list, such as that prepared by the National LP Gas Association, will be suitable.

It is also required that the supplier make a check of each of the tankers before it enters the property to ensure at minimum that the valves on the cargo tank are closed, that the connections are bled free of propane and where required capped, and that the tanker is filled only to the proper level - not overloaded. Each tanker must carry a copy of the company's instructions on the safe operation of the vehicle on the road and while discharging product to the customer's storage tanks.

2.3.3 Tankers on Site

All tanker movements on the property must conform to the codes already established by OC Transpo. In addition, propane tankers will be required to keep within the designed fuel delivery and discharge area and the driver must:

- NOT smoke while on site
- NOT leave the vicinity of the vehicle while on site; i.e. keep the vehicle in sight to ensure that unauthorized persons do not tamper with it
- Check the area for possible hazardous conditions, such as obstacles and possible sources of ignition
- Promptly remove the vehicle from the property in the event that unloading cannot proceed or unsafe conditions are noted
- Remain with the tanker in the event that collision occurs on site with an obstacle or other vehicle until advised to do otherwise by authorized OC Transpo personnel.

2.3.4 Unloading the Propane Tanker

The tanker driver will check for hazards in the fuel unloading/storage area and when satisfied that no hazards exist, will proceed and park the tanker in the designated position to make the delivery. The hand brake will be applied, and chocks put in place to prevent the vehicle rolling during propane delivery. An allowable alternative to the use of chock blocks at the rear wheels is available when the tanker contains a fail-safe braking system that is interlocked with the pump power take-off.

The movement of tankers and fracture of the delivery lines during transfer would create serious spillage hazards and MUST BE AVOIDED, despite the fact that a flexible coupling or connector (not longer than 1 metre) may be in use to compensate for stresses and vibrations.

Bonding leads for the discharge of static electricity will be connected between the tanker and the grounded propane transfer lines before the propane is pumped from the tanker. The leads are to remain

connected during the delivery operation and disconnected before the vehicle is driven away.

The truck tanker driver is responsible for the safe operation of all equipment on the vehicle, including the piping or hose used to transfer the product and will ensure that where signs of wear or deterioration or other damage are apparent in the reinforcement material of the hose or the hose connectors, they will be replaced immediately. The transfer lines beyond the connector are the responsibility of the OC Transpo fuelling staff and all hose, piping and connectors in this system will also be regularly inspected and if deficient, immediately replaced. The tank truck driver IS NOT AUTHORIZED to operate the OC Transpo storage facility and NO DISCHARGE OF PROPANE IS PERMITTED EXCEPT WHEN THE TANKER DRIVER AND THE OC TRANSPO FUELLING MECHANIC ARE BOTH PRESENT.

The sequence of operations required of the tanker driver to discharge the product will differ somewhat with different equipment, but in most cases the routine will be as follows with the connections as shown in Figures 3, 4, and 5:

- Open the valves on the vehicle to the delivery hose (at this point it may be required to engage the fuel meter if this is the method of measuring the volume delivered).
- Set the engine power to the idle setting required for pumping
- Remove the dust caps or plugs on the liquid and vapour transfer lines
- Connect the valved liquid and vapour lines from the tanker to the appropriately marked storage tank connectors
- Increase the speed of the engine to the required pumping velocity
- Gradually open the manual valves in the connecting hoses to deliver fuel to the stationary storage tanks and receive vapour from the tank vapour line
- Remain by the tanker ready to close the liquid and vapour emergency shutoff valves maually or by remote control or to respond to other problems that will require the fuel pump/vehicle engine to be shut down and the vehicle secured.

At this stage the OC Transpo staff will:

- Remain in place while the product is transferred to the storage tank to the required gauge level. DO NOT OVERFILL.
- Check the pressure regulator on the storage tank to ensure that

the vent is not blocked by dust or other debris.

- Close the vapour and liquid shutoff valves from the storage tank and, if a fixed level gauge is in place, close it also.

- Loosen the vapour and liquid hoses and valve (also vapour valve if incorporated in the vapour line) from the tank connections to ensure that the valves have sealed before completing the disconnection.

- Replace the caps on the fill connection of the storage tank.

- Record the time, date and volume of fuel taken to storage.

At this point the vehicle driver will:

- Cap the hoses and valves, disengage the power take-off and return the engine to normal idle speed.

- Close the truck tank outlet valves.

- Reel in or otherwise wind the transfer hose and secure it on the vehicle and bleed down all connections.

- Complete the delivery documentation required by the supplier and DC Transpo recording the time, date and volume of fuel delivered.

- Disconnect the grounding leads.

- Inspect the vehicle, exterior hoses, valves and other equipment prior to departure.

- Remove and store the wheel chocks (unless automatic and fail-safe braking/pump system is used).

- Drive the vehicle off the site on the designated route.

Note that the propane tank in the truck is NOT EMPTY. Even after full discharge of liquid it is still filled with propane vapour which is still a potential source of fire.

At some sites where smaller vehicles and smaller transfers of propane are involved, alternative fuel transfer systems can be operated and it is not necessary to operate a closed vapour-liquid system for transfer between the tanker and the bulk storage tank. In these cases the stationary storage tank will be equipped with a bleeder valve for the exit of vapour from the storage tank as it is displaced by the incoming heavier liquid propane. The fuel transfer process therefore includes the steps of opening the bleeder valve before propane transfer, keeping the bleeder valve open until it delivers liquid propane (mist or

white plume) when it must be closed manually (USING GLOVES AND A PROTECTIVE SLEEVED COAT) immediately after the delivery hose valve is closed.

With this system in use it is possible to determine the volume of propane which can be taken into the storage tank by means of a maximum liquid level gauge and to fill to that level before closing the liquid transfer valve. The maximum level to which the tank can be filled varies with the ambient temperature and a table of allowable volumes at each temperature is posted at the storage tank.

For tanks with 4500 litres capacity or more, the maximum fill at 38°C (100°F) can be 95% of the tank (water) volume; at -40°C (-40°F) the maximum is only 72% of the water capacity of the fuel storage tank.

2.3.5 Bulk Deliveries: Principal Hazards and Remedies

Experience over the past 20 years of bulk deliveries by tanker truck to storage sites shows that handling propane is no more hazardous than handling gasoline. The following description highlights the major hazards and remedies to be taken in the event of equipment malfunction or error and is meant to serve only as a reminder, rather than as a definitive check list of procedures. The safety check lists, staff training and safety drills will be specifically designed for each site where large volumes of propane are handled.

Tanker Entry to the Storage Area

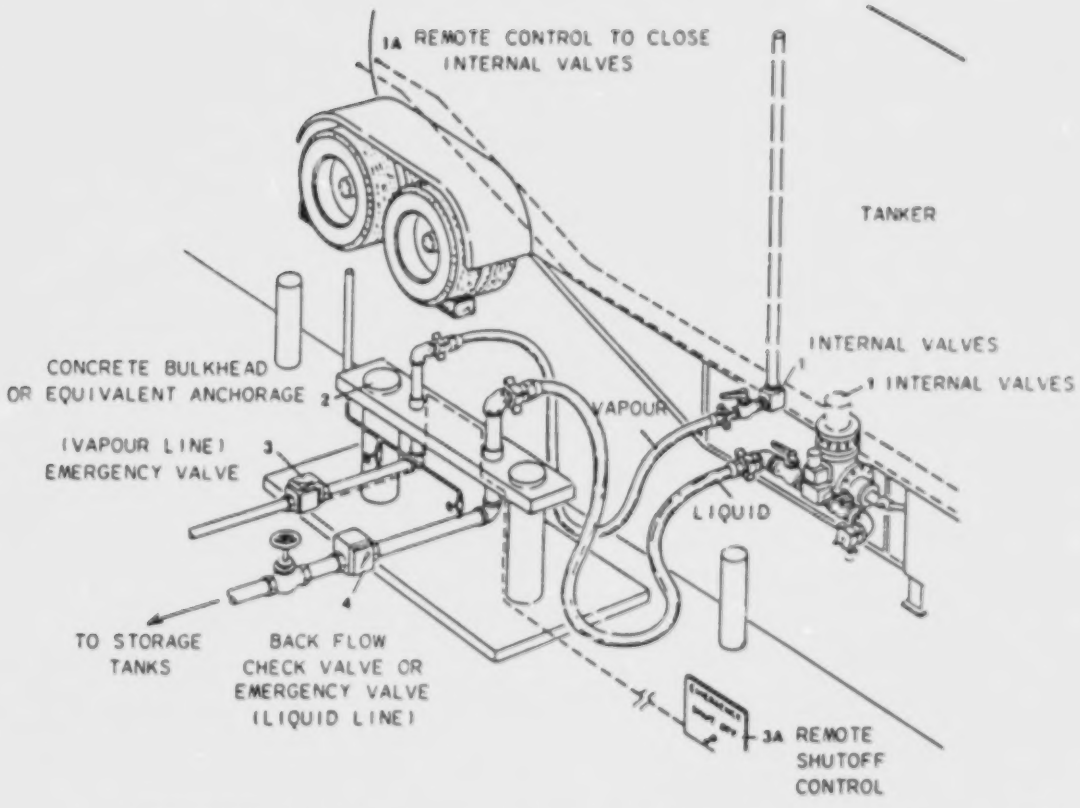
Before entering the property the vehicle will have been checked for safety and the presence of the required decals indicating a propane load. The vehicle will carry approved fire extinguishers. The driver must enter the area slowly and keep a look-out for hazards, especially potential sources of ignition in the fuel discharge area, such as other vehicles or open flames and people smoking. The driver should avoid reversing the tanker on site and must be certain that the vehicle is braked throughout the unloading process using chocks if an interlocked pump-braking system is not used. The engine should be stopped, except when it is used to drive the on-board pump. The driver must remain close by the tanker throughout the unloading process.

Unloading Propane

Attention to safety is the first and foremost consideration at all stages of the fuel transfer process: severe personal injury, fires, and even explosions may result from malfunctioning equipment or serious human error. The staff responsible for the operation of equipment and handling of propane must understand the properties of the product and be familiar with the relevant sections of the code relating to vehicle fuelling and product delivery.

Figure 5

Bulk Propane Unloading



TRANSPORTS must have the following safety devices unless emergency valves are provided at transport end of hoses.

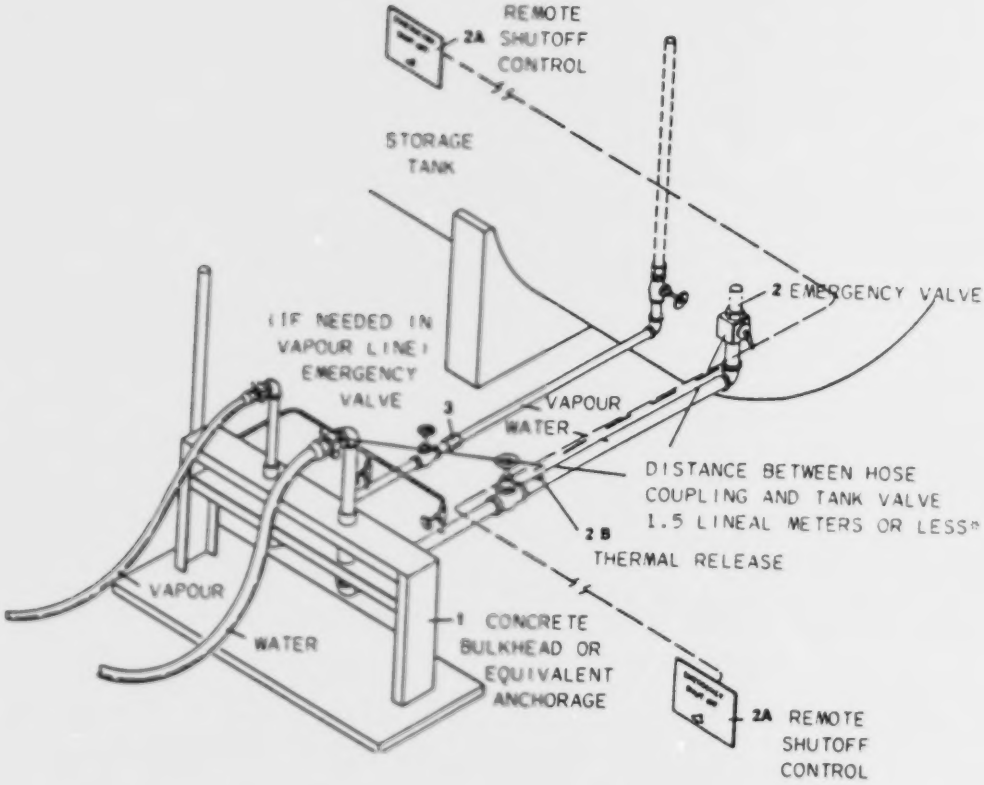
1. Internal valves, which include a manual means for shutoff at the internal valve and thermal release (temperature sensitive element) at internal valve, within 1.5 meters (5 ft.) of hose. 1A - remote control to close internal valves.

The BULK PROPANE UNLOADING AREA must have the following safety devices:

2. A concrete bulkhead or equivalent anchorage, with a predictable breakaway point to retain intact the valves and piping on the plant side of the connections is required.
3. The vapour line must have an emergency valve with means for manual shutoff, thermal release and remote control provisions. 3A - remote shutoff control.
4. The liquid line must have either a back flow check valve (may be part of sight flow unit) or an emergency valve with means for manaul shutoff, thermal release and remote shutoff control.

Figure 4

Bulk Storage Tank Connections



Single storage containers of over 15,000 litres water capacity, or stationary multiple container systems with aggregate water capacity of more than 18,160 litres utilizing a common or manifold liquid transfer line, shall have the following safety devices:

1. Concrete bulkhead or equivalent anchorage.
2. Emergency valve with means for manual shutoff at the valve. 2A - remote shutoff control. 2B - thermal release within 1.5 meters from the nearest end of the hose, or swivel-type piping.
3. Vapour line does not require an emergency valve when the hose diameter is less than 31.8 mm (1¼ in.).

* NOTE: For storage tanks located more than 6 meters lineal pipe distance from hose connection and when vapour hose or swivel type piping is larger than 31.8 mm (1¼ in.), the bulkhead design in Figure 3 must be used. An emergency valve is then required.

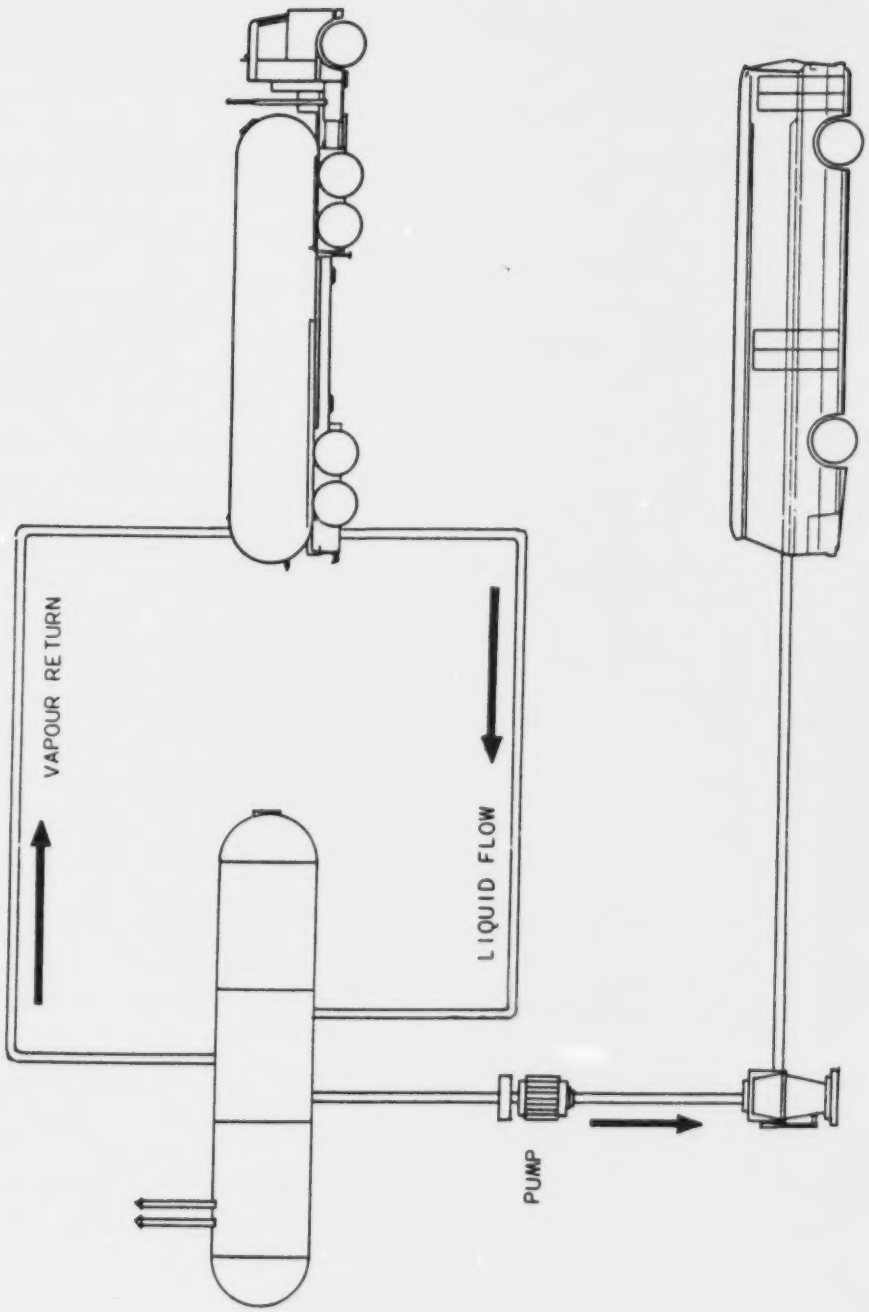


Figure 5
Tanker Vapour Lines

Responsible personnel will be trained in the fundamentals of fire fighting and fire control associated with propane. They will be trained in the correct handling of fire fighting and fire control equipment and will be drilled in this respect at frequent intervals. Staff responsible for propane loading will be familiar with the location and functioning of all gauges, piping and valves in the fuel storage and transfer area. These systems must be checked to ensure that they are in safe working condition before product transfer is made from the tanker and that only the valves required for the transfer are open. The staff should also check that the procedures required at the truck tanker have been followed: this double checks the procedures required from the driver.

Checks are to be made to ensure that: brakes and/or wheel chocks are in place; electrical and driving units not needed to transfer propane are stopped or isolated; static electricity connections are made to suitable ground before transfer begins and that checks are made before the truck tanker is moved from the unloading site that electrical, liquid and vapour connections have been disconnected.

The person in charge of the unloading operation should ensure that the transfer operation is stopped and all valves closed if there is a severe electrical storm or fire in the vicinity, or if an uncontrolled leak of propane occurs.

During the unloading operation employees are required to wear protective headgear, eyeglasses and vinyl-coated safety gloves. A small volume of propane liquid will always boil off when hoses are disconnected and propane escapes from the bleeder valve of the storage tank, if that system is used. The boiling liquid propane can cause an injury similar to frostbite. Employees should never look into hose connections, since propane could accidentally discharge from the connection and cause eye or facial injuries.

In the event that a serious leak or spill occurs in the unloading process, the OC Transpo employee responsible for the operation will:

- Instruct the tanker driver to stop the flow of product (shut off the pump and engine) but will not uncouple the transfer hose
- Call the Chief of the Security Department for help. The Security Department will call the fire department, and if necessary, the police
- Not permit the tanker or any vehicle in the immediate vicinity of the spill to start up
- Instruct non-essential personnel and other vehicles in the area to evacuate

- Cut off power switches, heaters and other potential sources of ignition

- Await instruction from the Chief of the Security Department before restarting the unloading operation

- Promptly complete an ACCIDENT REPORT FORM at the Security Department office, which department will issue and file copies as appropriate to the severity of the leak or spill and hazard.

In the event that a fire occurs in the case of a pipe or hose leak, the OC Transpo employee responsible for the unloading operation will:

- Instruct the truck tanker driver to shut off the engine and pump

- Stop the flow of product activating the emergency shutoff valve and alarms if a fire occurs in the truck tanker

- Call the Security Department who will call the fire department

- Use discretion whether to fight the fire with the extinguishers at hand or to await the arrival of the fire department (there is no virtue in extinguishing a fire unless the propane supply can be turned off since an explosion hazard greater than the fire hazard may be created)

- Give instructions for evacuation of the area and stop equipment as described above for a major spill or leakage

- Promptly complete the ACCIDENT REPORT FORM when activity allows.

The alarm, firefighting and fire control procedures are described in Section 5.

3. PROPANE STORAGE

3.1 Storage and Refuelling Options

There are hundreds of bulk storage plants and over 2800 vehicle fuelling stations and a large number of cylinder filling plants in Canada with an impressive record for safety. An extensive system of regulations, codes, common sense practices and continual improvement of equipment contributes to this safety record. Developments are most rapid in the regulations and equipment used in the storage and dispensing of vehicle fuel.

Control of bus operations, costs and overall safety requires that storage and refuelling islands be available at each garage despite the fact that at certain locations in the U.S. daily refuelling of even large fleets is provided as an on-site service by the propane suppliers using mobile fuelling facilities with the advantage that only an emergency supply of propane need be stored at each fleet garage.

3.2 Location of Storage Tanks

The storage tank area is chosen to provide easy access to truck tankers delivering fuel and to the bus fuelling stations while at the same time taking advantage of the terrain to improve safety at the total site. The location of the tanks on the site is chosen to provide the maximum opportunity for propane vapours to disperse into the air when they arise during fuel transfer, venting of relief valves in the storage vessels, or from system leaks.

The tanks are therefore clustered and situated to take advantage of the prevailing wind on site and to avoid features at the site which may channel propane into the garage, across the refuelling station onto the road or railway or any other place where people, vehicles and sources of ignition may be found.

The layout of the storage area will also avoid channelling of propane to gulleys, pits, or other depressions where the vapour may collect and where mixing with air may be slowed down. In general, dikes, walls, solid fences, or other structures are not advisable since while they may contain an explosion, they defeat the main purpose of an open air tank system which is to prevent gas accumulation in the first place. The site and the location of individual tanks within the storage area will have the approval of the Fuels Safety Branch of the Province (in Ontario this function resides with the Ministry of Consumer and Corporate Relations) and of the safety and engineering departments of the municipality.

At some locations in N. America, conditions are such that propane tanks are sited underground - the common practice with gasoline storage. Burying propane tanks is not recommended as a general practice since above-ground systems provide greater visibility in case of leaks and are readily accessible for inspection and service. Pumping system maintenance is generally easier and less frequently required with above ground tanks than with underground propane tanks.

The location of propane tanks with respect to each other, to other fuel tanks, to property lines, to electrical transmission and distribution lines, and other potential sources of ignition, is strictly controlled by law. The Canadian requirements summarized in Table 3 are taken from the Ontario Propane Standard No. 2/81 which is enforced in Ontario by the Fuels Safety Branch. In heavily built up areas, the siting conditions may be much more restrictive than those shown in Table 3 and each major site must have specific, individual approval of its tank arrangements.

Entrance to the fuel storage area must be restricted to those responsible for the operation and servicing of the equipment and for the delivery of propane to the storage area. The fuel storage tank is fenced off from the rest of the garage but this is not strictly necessary when each storage tank is equipped with a ventilating cabinet approved by the Fuels Safety Branch which provides security to the pump, meter and dispensing hose associated with each storage tank. Fencing is recommended in the present case to relieve the burden of controlling the entrance to the garage at all times and yet to provide protection against tampering with the equipment and instrumentation. For this reason the storage area is to be kept lit throughout the night by safety approved lighting systems.

The fuel storage and transfer area is signposted to indicate it is off-limits to employees other than those with a need to enter. Appropriate signs are placed to warn against entry by unauthorized vehicles or use of non-essential equipment, cigarettes or other potential ignition sources. The location of any underground cables and propane pumping system is similarly posted. Good area maintenance practices such as regular weed and rubbish removal assist in maintaining safety standards.

3.3 The Tanks and Supporting Equipment

The tanks for storing propane must have a design pressure not less than 1750 kPa (250 psig) each of which is approved by the Boiler and Pressure Vessels Inspection Authority of the Province (the tank will conform to CSA Standard B51 "Code for the Construction and Inspection of Boilers and Pressure Vessels") as are any major changes to the vessel such as welding. The tanks must be regularly inspected and kept painted. The standards for installation of a tank on concrete pads or piers depend on whether the tank is to be erected in a horizontal or

Table 3

Required Clearances for Propane Fuel Storage Tanks

Total Water Capacity of Tanks (litres)*	Property Lines; Walls, Buildings, Drains & Open Flames	Adjacent Propane Tanks	Underground Gasoline or Other Fuel Tanks
Up to 7580	7.6 m (25 ft.)	0.9 m (3 ft.)	7.6 m (25 ft.)
7581 to 37,900	15.2 m (50 ft.)	0.9 m	7.6 m
Over 37,900	30.4 m (100 ft.)	0.9 m	7.6 m

MINIMUM CLEARANCE FROM ELECTRICAL LINES

Transmission Lines:

1. Location of tanks under overhead lines prohibited
2. Location on surface minimum: horizontal distance as for property clearances above

Distribution Lines:

1. Not over an underground line and not less than 1.5 m from such a level
2. Tanks not under an electrical distribution line and not less than 7.5 m from such a line

* Note that propane capacity will be substantially less to allow for expansion. The permissible level of filling of each tank will be determined by the temperature-fill capacity table which will be permanently located at each storage tank.

vertical orientation but in all cases the ground is prepared for proper drainage with a gravel drainage base and provincial regulations followed regarding the number and location of support structures, the corrosion protection provided metal supports and so forth.

Special provisions relate to the design and erection of vertical tanks. For horizontal tanks the distance between the tank and the grade pad or slab must normally not be in excess of 76 cm (30 in.) or less than 15 cm (6 in.).

Each storage tank on the site is provided with:

- relief valves
- an emergency shutoff valve
- a combination back check valve and excess flow valve
- a pressure gauge
- a liquid level gauge
- a ventilated cabinet for the protection and security of the pump, meter and dispensing hose

Each tank with a ventilated cabinet has post or guardrail protecton to ensure at least 3 meters (10 ft.) clearance between the meter or pump outlet and any source of ignition including vehicles positioned for refuelling. At the OC Transpo site the propane dispensing islands are located at a greater distance from the storage tanks. 7.6 meters (25 ft.) is the minimum separation distance allowed between the storage tanks and any building, drain, underground fuel tank or building.

Underground piping from a storage tank to a remote dispensing island must be of steel construction (not less than Schedule 80 steel) with steel fittings and buried not less than 0.9 meters (3 ft.) below grade in the traffic area and further protected by being run within a steel or concrete chase. In non-traffic areas the underground piping must be not less than 38 cm (15 in.) underground.

The relief valves have direct communication with the vapour space in the tanks and are arranged to minimize tampering. The relief valves vent propane when a tank pressure in excess of the valve setting is reached, for example by unusually high ambient temperatures when the tanks are at the maximum fuel level. A well-maintained coating on the tank minimizes the frequency of this event. Infrequent venting through the relief valve is expected but excessively frequent venting requires examination of the valve and the tank filling practices. However the relief valve must not be adjusted to too high a pressure to prevent the normal venting of propane. The relief valve is installed to vent the gas upward and unobstructed to the air via the relief valve discharge pipe which will discharge vapour 2 meters (7 ft.) or so above the tank. It contains a rain and dust cap to minimize water, snow and debris accumulation at the relief valve.

The emergency shutoff valve is included with each tank or manifolded set of tanks on site with a volume (water volume) of 15,000 litres or greater. The emergency shutoff valve can be closed manually by the fueller at the tank location and also automatically (switched) from a remote location. The emergency shutoff valve is installed in the piping system along with the back check valve/excess flow valve so that any break resulting from a pull (drive away of a vehicle with the fuel hose still attached to the vehicle) will occur on the hose or swivel piping side of the connection. As shown in Figure 4, the emergency shutoff valves are anchored in reinforced concrete bulkheads. A shear point is incorporated in the piping downstream of the emergency shutoff valve and the bulkhead storage.

In addition to the emergency shutoff valve in the piping system, each tank contains a plugged type combination excess flow valve and back check valve designed for liquid flow. The size shall not be less than NPS 3/4.

The storage tanks are provided with a pressure gauge and a fixed liquid level gauge which indicates the maximum liquid level to which the tank may be safely filled. The length of the dip tube with the letters "DT" is stamped on the exterior of the tank and on the gauge. The filling level MUST NOT exceed that specified but it is also important not to draw down the liquid level to too low a value: a "heel" of liquid propane in the tank of not less than 5% of the storage tank capacity is advisable.

To increase safety and improve working conditions, the storage tank is protected from severe winter conditions by fitting each storage tank with a ventilated cabinet. When such a cabinet is used, regulations dictate that only certain components may be located within the cabinet and others must be located outside. The regulations require that the main switch for the propane pumping system, the fuel pump and the piping between the pump and the liquid outlet port of the tank and piping from the bypass valve to the bulk tank be located within the cabinet. The relief valve, the liquid gauging device and its filler valve must be located outside the cabinet.

The ventilated cabinet approach is particularly useful in medium scale and start-up operations where very large volumes of propane are not dispensed hourly. Under these circumstances the area for transfer of propane from road tankers and the vehicle refuelling area can be common and the ventilation cabinet controls can be used to control vehicle refuelling. [Under other conditions where low volumes of propane are transferred, an alternative fuel transfer system which does not require a closed vapour-liquid system with dual piping and valving can be used. Here the storage tank may be fitted with a rotary or slip tube gauge connected to a bleeder (or fuel outage) valve which is open manually at the start of liquid transfer, held open during bulk propane transfer and closed when liquid appears at the bleeder valve as a white

plume. The gauges may be set to vary the extent of the maximum of fill which can be taken into the tank which varies with the prevailing temperature.]

For the OC Transpo fuelling system, the bulk tank filling operation and the vehicle refuelling operation are separated as much as possible within the constraint that they both focus on the bulk propane tanks. The ventilated cabinet controls at the horizontal bulk storage tanks provide a degree of redundancy with other controls located at the vehicle refuelling islands. The electrical wiring, equipment and fixtures located within 7.5 meters (25 ft.) in all directions from the storage area, tank valves, pump, compressor, and all points of fuel transfer must conform to the Provincial Electrical Code (CSA Standard C.22.1 "Canadian Electrical Code" for Class 1, Division 11, Group D hazardous locations).

3.4 Safety Precautions and Practices at the Bulk Propane Storage Facility

The safety precautions to be followed are in four areas:

1. Specification, certification and control of equipment at the manufacturing and installation stage

2. Inspection and maintenance of equipment installed at the site

3. Training and refresher courses on safe operation, inspection and maintenance of the bulk storage equipment

4. Emergency procedures and training for emergencies.

3.4.1. Equipment and Installation

Very detailed Codes and Regulations are in place which closely define the material, workmanship, pressure testing, electrical requirements and other controls placed upon the manufacturers and installers.

Once the installation is certified it is the responsibility of the operating company to provide inspection and maintenance of the equipment and to provide and maintain the signs and displays at the site.

The signs required include:

- "NO SMOKING" signs or symbols at all entrances and points of propane transfer. (These conform to provincial regulations; the lettering on signs is required to be at minimum 100 mm (4 in.) high, red on a white background, and the symbols must have a minimum diameter of 300 mm (12 in.).

- signs indicating the tank storage area is off limits to unauthorized personnel
- signs indicating the location of fire extinguishers and other safety apparatus
- route signs and markings for tankers
- signs indicating the location of underground piping and electrical cable
- warning signs and labels on individual components as required by the regulations (Figure 6 gives an example of the labelling that must be attached by the manufacturer of above ground propane storage tanks)
- posted instructions to tanker and other vehicle operators in the area
- posted instructions on procedures to be followed in the fuel transfer step
- posted instructions on procedures to be followed in the event of a propane leak or fire.

3.4.2 Inspection and Maintenance of Installed Equipment

There are daily and monthly inspection routines. The daily inspections at the tank site include:

1. Inspection of the main electrical switch, the pumps, valves and exposed hose to ensure that they are in working order and are not leaking (soapy water to be used for testing of suspected leaks - NOT A FLAME).
2. The fire extinguishers and other rescue equipment are in place and in good working order.
3. The fencing around the installation is intact.
4. The roadway to the tank area and the areas between tanks are clear of vehicles, debris, or other items which may impede access to the tank area for maintenance, repair, fuel transfer or fire fighting purposes.
5. Checking of the communications system from the tank area to the Security office.
6. A CHECK LIST of the inspection be completed and a copy provided to the Chief of Security and Manager of the Equipment Department (Engineering).

Figure 6

The Propane Tank Manufacturer's Label

MANUFACTURERS' NAME
FOR LP GAS ONLY MAX D.P. _____ PSI AT _____ °C YEAR _____ MANUFACTURER SERIAL # _____ CAPACITY _____ LITRES SURFACE AREA _____ m^2 CRN _____ O.D. _____ O.L. _____ HD 2:1 SHELL THICKNESS _____ HEAD THICKNESS _____
CAUTION: THIS CONTAINER SHALL NOT CONTAIN A PRODUCT HAVING A VAPOUR PRESSURE IN EXCESS OF 1500 kPa AT 38°C

The monthly inspections at the tank site include in addition:

1. Inspection of tanks for corrosion, paint flaking, other distress.
2. Checking the fire alarm system (to be included in the quarterly fire drill), the water hydrant and the communication line to the fire department.
3. Inspection of the pipeline pathway for signs of leaks, movement or damage.
4. Inspection of the signs and decals in the tank area.
5. Review of daily reports and issue of a MONTHLY SAFETY REPORT with copies to the Security Office and the office of the Manager of the Equipment Department.

Other inspections will be required at longer intervals as specified on equipment by the manufacturers and the responsible Provincial agencies.

3.4.3 Training and Refresher Courses

Those responsible for the transfer of propane on site will have undergone a training course. At least one employee on each shift in the fuel transfer area will have a P3 or P3A certificate issued in Ontario by the Ministry of Consumer and Commercial Relations. Information bulletins from the Fuels Safety Branch or other agencies and from suppliers will be available for reading in the library and new information on safety and maintenance will be circulated among the responsible staff.

Refresher courses on the safe practices to be used in fuel transfer will be provided from time to time.

3.4.4 Emergency Equipment Procedures and Training

An Emergency Response Plan for the site will be approved by the General Manager, the Chief of Security, the Manager of the Equipment Department, the foreman of the fuelling operation and tank areas, and by the municipal fire department.

The plan will be reviewed and revised annually or more frequently if equipment and safety experience indicate this to be necessary.

The key elements of the plan will be posted at the fuel transfer site, within the equipment department, the security department and prominently within the garage. Current copies of the detailed plan will be maintained within the office of the General Manager, the Manager of the Equipment Department and the Chief of Security and by the foremen of the fuelling operation. Current copies will be provided to the municipal fire department.

The key details of the Emergency Plan will be reviewed at the

refresher courses on safe practices to be used in fuel transfer. Routine safety and fire drills will include practice in implementaion of the parts of the plan which can be conducted without severe disruption of bus and garage operations.

The key requirements of the Emergency Response Plan are given in Section 5.

Although an Emergency Response Plan may be in place, the keys to safe operations are:

FAMILIARITY WITH EQUIPMENT AND SAFE PRACTICES
- achieved through training (certification), refresher courses and posted instructions at the site.

INSPECTIONS AND MAINTENANCE
- which shall be frequent, regular, thorough and reported.

AWARENESS
- among personnel of the properties of propane, the ways to avoid leaks and spills and the steps needed to contain the spread of vapours and the fire hazard.

CO-OPERATION
- in the running of the expanded safety program.

4. VEHICLE FUELLING

4.1 Equipment

Equipment for dispensing propane to vehicles is undergoing rapid development and a draft of standards being proposed by the Canadian Gas Association, such as the proposed standard CGA 12.4 "Dispensing Devices for Propane Fuel for Highway Vehicles", dated July 1983, was available for reference at the time of writing. This document should be referred to for details of the proposed and existing standards. Current dispensing systems are unable to deliver propane at the rate required to give a 3 minute fill of the manifolded tank in each bus, and hose nozzles (pistol type) are under development which can reduce the connect/disconnect time to the vehicle and speed up the vehicle tank fill. New standards may be needed for these.

The bus refuelling system is designed to refuel more than one bus from each island, each of which is operated by a trained and certified refueller. The islands contain a weather-proofed and ventilated housing anchored to a concrete base. The island has a plastic roof to further protect the refuelling staff and the equipment from the weather. Consideration is being given to means to heat the island areas by ignition-protected indirect heating sources.

The exterior of the fuel dispenser housing provides a means for storing the fuel hose nozzles (or pistol) when not in use, and is fitted with a substantial holster or nozzle guard. Within the ventilation housing are contained connections to the valved steel piping system, which leads to the storage tanks, and certified electrical connection. The design is such that easy inspection of the interior of the housing is possible. Other components of the fuelling system are:

- a dispensing hose of approved material and length not greater than 3.5 metres (10ft.) and a minimum working pressure of 2400 kPa (350 psig)

- an automatic quick-closing coupling (which closes in both directions when uncoupled) within the dispensing hose to minimize the escape of propane should a vehicle inadvertently drive off while still connected (this is reported to be the most frequent safety incident on refuelling)

- a hydrostatic pressure relief valve installed between each pair of shutoff valves on the propane hose with its outlet aimed so that escaping propane will not impinge on other propane-containing components

- a visible discharge indicator with an excess flow check valve installed at the fuel inlet side of the indicator

- a meter fitted with a strainer upstream within the hose

- (the system may contain a pump if pressure boosting for flow rate is required beyond that provided by the remote fuel pump located within the ventilated cabinet of the bulk propane storage tank which serves the fuelling island).

Other features which improve the safety of the refuelling operation include:

- a hose nozzle design such that the propane supply is shut off unless the filling nozzle is secured to the vehicle filling connection

- a manual (dead man) flow control that shuts off the propane supply when the manual controlling force is released: the dead man control is located at the filling connection and requires a manual action (or trigger) other than lifting the nozzle from its position on the dispenser. Other systems have the dead man manual control located on the dispenser cabinet.

- the whole island is controlled by an automatic shut-off control system which operates in parallel with a similar control located in the ventilated cabinet of the bulk propane tank: the shut-off control is illuminated at night

- the pump control is secured by a padlock when not in use

- each dispensing device is fitted with a tamper-proof lock (padlock) which is used to secure each nozzle valve when the island is not in operation

- each island contains NO SMOKING signs and other signs to guide the safe refuelling operation

- the fuel lines from the islands are connected to one of the bulk propane tanks by corrosion-resistant high pressure rated steel pipe, which is buried within the fuelling area and which in the above-ground sections contains relief shutoff and other valves required by safety considerations and the Provincial regulations previously described for the bulk fuelling system.

4.2 The Fuelling Step

1. The bus (or other vehicle) is driven to the barrier at the fuelling island, the handbrake applied, the motor stopped with automatic transmission in 'neutral', manual transmission in the

lowest gear.

2. The driver and the fueller will check for possible sources of ignition. NO SMOKING is permitted and the fueller may not carry a lighter, matches, or other sources of ignition or flame.
3. The driver will not assist the fueller in the fuelling operation, but wait outside the bus until completion of fuelling and the signal from the fueller is given to promptly remove the bus from the area.
4. The fueller must wear protective gloves, a safety shield or safety glasses and a sleeved coat.
5. The fueller must determine from the vehicle fuel gauge whether the bus requires propane fuel.
6. If the vehicle fuel gauge gives a false reading and less fuel than indicated is required, this must be reported to the fuelling foreman (who will assign the bus for repair).
7. The fueller will remove the protective cap from the vehicle fuel inlet system, connect the hose nozzle, check the pump is in operation, and stand by the filling valve during filling to the 80% fixed fuel level only.
8. The fueller will open the 80% fixed level fill valve (bleeder valve) and stop fuelling when the 80% level of fuel in the vehicle tank is reached. (If the fueller contacts the fuel, the system should be shut down and the fueller will report to the nurse for first aid - see Section 4.3.1).
9. The pump will be shut off and the valves closed.
10. The hose nozzle will then be disconnected and the cap on the fuel inlet at the vehicle will be replaced.
11. The hose and nozzle assembly will then be returned to the holster in the housing at the island.
12. The fueller will instruct the driver to enter the bus and move off the fuelling area after the fueller has once again checked that the vehicle is not connected to the hose.
13. The fueller will lock the hose nozzle assemblies and the automatic shutoff switch before leaving the island unattended for more than 5 minutes.

4.3 Possible Problems and Required Responses

4.3.1 Contact with Propane

Although company regulations insist that protective clothing and eyeware be worn at the refuelling site, it is possible that an employee may inadvertently come in contact with liquid propane (for example, from a bleeder valve or on making a hose disconnection). Contact of the skin with the rapidly vapourizing and cold liquid may cause a form of frost bite and the victim should report the incident in an INCIDENT REPORT after checking with the nurse. Where the severity of exposure warrants, the nurse will place the victim in a warm place to allow the injured area to warm gradually and cover the area with a clean dressing. A warm non-alcoholic drink is helpful. Pain may be relieved by immersing the

affected area in tepid water (about 37° to 40° C). The injured area should be exercised at the discretion of the nurse and the victim returned to work, or further medical advice sought. The nurse will record and report each treatment in the usual way.

Propane is non-toxic and the occupational hazard is not much different from that associated with other inert gases: if there is a very high proportion in the air, then oxygen deprivation will cause asphyxia. The recommended maximum 40 hour work week exposure level has been set at one part in a thousand of the air.

4.3.2 Leaks

The equipment is designed to automatically shut down in the event that major leaks or line rupture occur.

The daily recorded inspections at the fuelling area and at the storage tanks (Section 3.4.2) aim to keep this component of the safety system in first class condition. Slow leaks or malfunctioning of equipment requires independent action by OC Transpo personnel. When a LEAK is detected it will be isolated and the hazard minimized in the following way:

1. Close all valves upstream of the leak or discharge.
2. Throw the main switch of the electrical system to stop pumps and reduce ignition sources.
3. Block off the danger zone. Only authorized personnel are to remain in the danger zone.
4. Do not allow any bus or other vehicle to start up its engine.
5. Inform the foreman who will alert the security office, and in the event of a major leak, the fire department and the General Manager. If the foreman is absent, call Security directly.
6. Close valves downstream of the leak of discharge, thereby isolating the leak or discharge.
7. Assist the natural process of propane dilution with the air with a fine water spray.
8. Resume operations when instructed by the Security Officer.
9. Complete an INCIDENT REPORT with copies to the foreman, the Chief of Security, and the Manager, Equipment (Engineering).

In general, the site regulations provide that no unaccompanied person or person untrained in fire control will work in the fuelling area.

4.3.3 Overfill

In the event that the fuel tank is OVERFILLED, the vehicle is not to be garaged and must be driven immediately to the designated fuel discharge area (situated away from the garage and other buildings, the fuelling area, storage area and other potential sources of ignition).

The vehicle will be parked, the engine stopped and excess propane vented to the air through the fixed liquid level valve (spitter valve). Two people should be present during this discharge procedure.

4.3.4 Fire

In case of a FIRE being detected in the area, the following actions are to be taken:

1. The observer will call for help from other trained personnel at the site.
2. The observer will immediately contact the Security Office on site which will then alert the fire department to stand by, call the local fire control unit and, if appropriate, sound the general alarm.
3. The observer, if trained in fire fighting and certain that the fire can be promptly extinguished with the equipment to hand, may delegate the call to the Security Office to any other person present in the area, or under exceptional circumstances only (when the fire is small and can obviously be brought under control quickly) proceed directly with the fire control process.
4. The trained personnel will shut off the valves upstream of the fire before the fire extinguishers are used. (This avoids the hazards of an extinguished fire in the presence of propane vapour serving as an ignition source for a further fire or an explosion).
5. All unecessary personnel will be evacuated ON FOOT from the hazard area (no vehicles to be started up).
6. The main switch of the electrical system is to be shut off to prevent pumping of propane.
7. The valves on the propane system downstream of the fire will be closed to limit the propane available to feed the fire.
8. When the sources of propane are shut off and only if they are, the fire will be extinguished by the use of the approved (solid type) fire extinguishers at hand at the fuel transfer locations.
9. In the event that the flow of propane to the fire cannot be stopped, or the fire is not promptly extinguished, then the fuelling staff will advise the Security Office of the circumstances and turn over the management of fire fighting and control to the fire department when instructed to do so by the Chief of Security. Trained staff will provide assistance to the fire department as requested, but not interfere with the execution of the Emergency Response Program by the fire department (which plan will be current and will have been worked out previously with the Chief of Security and the fuel-exposed trained personnel). A water spray to disperse the propane vapour will be activated and water hoses connected and cooling of storage tanks will be started. The emergency procedures detailed in Section 4.4 will then be instituted.
10. When conditions permit, INCIDENT REPORTS will be prepared by the foreman and other OC Transpo staff involved in the incident. The

reports will be issued to the Chief of Security, the Manager, Equipment (Engineering), the General Manager and to the fire department.

11. All enquiries regarding any propane incident or emergency shall be directed to the Chief of Security for response.

4.4 Fire Fighting Advice

The U.S.National LP Gas Association has prepared a series of pamphlets which summarize in pictures and words the procedures they recommend for containing leaks and small fires at fuel transfer locations. Copies of these pamphlets should be on display close to the working areas.

Their suggestions and those of others which are appropriate for bus fuelling include:

Basic Precautions

1. Approach a propane fire or leak from up-wind.
2. Keep all persons out of the vapour cloud area and, if necessary, evacuate any area within the path of the vapour cloud. Eliminate sources of ignition at this time.
3. Police the affected area. Keep all persons except those necessary to cope with the condition completely out of the area. The suggested minimum distances from the side of a propane tank are 300 metres (about 1,000 ft.) and from the ends of the tanks 600 metres (about 2,000 ft.).
4. Remove vehicles and other sources of propane or ignition from the possible path of the vapour cloud but DO NOT move those which are already within the danger zone.

Leakage Without Fire

1. If escaping gas is not burning, close valves to stop the flow.
2. Water spray is effective in dispersing propane vapour and should be used as soon as possible, directing the spray across the normal vapour path and dispersing the vapour into a safe location. Those handling the fire hose should avoid entering the vapour cloud and should keep low behind the spray to protect themselves from the radiant heat, if the vapour should unexpectedly ignite.

Leakage With Fire

1. The flame should NOT be extinguished, unless the leakage can be stopped.
2. Apply large quantities of water as soon as possible to all surfaces exposed to heat. Approach storage tanks from the side, concentrate the water stream on piping and metal surfaces of tanks and adjacent tanks, equipment or combustible surfaces exposed to

flame or intense radiant heat. Special attention is required to water cooling of the upper portion of the tank shell containing vapour (sometimes the liquid-vapour line is made visible in leaking tanks by a frost line). Water streams should be directed at two sides of a tank if possible.

3. The trained company fuelling staff will be responsible for stopping the flow of vapour after water cooling is established. They may perform the shut off under the direction of the fire department or provide advice to firefighters on the location and shut off procedures. If the only valve that can be used to stop the flow of fuel is involved in the fire, fire department personnel only will be involved and they will be protected by special clothing, gloves and water fog streams.
4. The controlled burning off of escaping propane (which has not been shut off by the automatic thermally sensitive shutoff valve or manually) is a common fire-fighting practice. Water cooling of the affected tank or piping will allow the fire to consume the product in the tank without danger of causing tank failure.
5. Dry chemical portable extinguishers are effective for extinguishing small fires. Carbon dioxide extinguishers are also effective. The extinguishing agent should be directed at the vapour discharge. Small fires which arise from sources other than propane can similarly be extinguished.
6. There are conditions where excessive heat at a storage tank, perhaps coupled with a failure to vent gas through the relief valve, could cause it to weaken at certain points and rupture under the pressure of the contained vapour. An extreme manifestation of this is the BLEVE (Boiling Liquid Expanding Vapour Explosion) which may create a fireball at the site as the propane tank ruptures. Any indication that a large tank in the fire area cannot be cooled, or that the contents are not burning in a controlled way, will require immediate evacuation of the entire site, as instructed by the Chief of Security, or the fire department.
7. The Chief of Security will activate emergency procedures at the propane fuelling site and storage area if a fire occurs on site, even when not in the propane area. The procedure will include the termination of fuelling and fuel unloading, the activation of emergency shut-down procedures, the evacuation of all vehicles from the propane fuelling and fuel storage areas and preparation for fire-fighting at the propane location, including where indicated, water cooling of the propane storage tanks.

4.5 Other Emergency Response Activities: An Emergency Plan

The method of dealing with problems that arise in the transport of propane (such as tanker accidents) require special measures, such as the careful transfer of propane to other vehicles, and special training: this is not reported here. The U.S. National Fire Protection Association and the National LP Gas Association have publications and other

instructional material available to those concerned.

Similar training aids and regulations are available to fire departments. The task for OC Transpo is to co-ordinate its emergency planning and training with the fuel transporters and with the fire department, making them familiar with the OC personnel they will encounter in an emergency at the site, the propane equipment, the fire-fighting and other security equipment available for an emergency. The fire department should be involved in the production of a plan to cover emergency procedures which will be followed BEFORE the municipal fire fighters arrive, and the responsibilities of OC Transpo staff at such a time.

The fire department and OC Transpo will be involved in at least the following:

1. The re-evaluation of the level of communication and alarms needed in the new (propane) circumstances.
2. The approval of colour coding and other means to assist firemen in the identification of propane storage valves, shutoff valves, power switches, in-garage ventilation systems.
3. The review of the plot and building plans which will identify the location of all major sources and pipelines for propane, possible sources of ignition and the location of water mains, extinguishers and other safety equipment. Copies of the plot plan and building plan will be provided to the fire department and maintained in a prominent position near the fuelling site, in the Security Department and the Equipment (Engineering) Department.
4. Review and evaluation of emergency procedures which will be activated by OC Transpo personnel and the conditions under which the fire department will be assigned responsibility.
5. Review of the fire department emergency plan and procedures with assigned OC Transpo staff.
6. Scheduled visits to the OC Transpo site to familiarize firemen with the site, equipment and emergency procedures.
7. Conduct joint emergency drills involving the municipal fire department and OC Transpo staff.
8. The fire department will receive and review safety incident reports from OC Transpo which deal with fire hazards and on-site or on-vehicle fires.

5. BUS CONVERSION TO PROPANE

5.1 Vehicle Rebuilding

The severe operating conditions in urban bus service and the requirement for high levels of vehicle reliability and availability require that specially designed heavy duty propane engines be installed. Engine replacement is a routine operation at most fleet garages and this capability will continue to be required when propane-fuelled buses are a major component of the vehicle mix.

Some new shop capabilities are required to service a propane fleet; these can be developed and used to rebuild existing buses or finish the manufacture of new buses to the propane configuration. A phasing-in of propane buses through a rebuilding program also provides the opportunity to train installers, maintenance and inspection personnel and to test new equipment and procedures, including the revised safety systems.

The rebuild involves the installation of new hardware:

- a prefabricated propane fuel system
- a pretested engine in its cradle
- prefabricated piping, hose and electrical connections

and the testing, inspection and certification of the vehicle before it is released for service.

In addition to changes in the vehicle, certain changes must be made within the garage to make it convenient and absolutely safe to garage, convert, test and repair propane buses on the property.

The extent of the changes and precautions necessary with the propane system should not be taken to indicate that working conditions at the garage will be more hazardous with the new fuel. The changes and precautions are designed to ensure that the hazards which always exist when handling gasoline, diesel, propane or any other fuel are recognized and that every step be taken to minimize risk.

5.2 Staff Qualifications

The safety procedures which must be taken for the installation of fuel lines and the interfacing of the engine and propane fuel tank at the garage are defined in provincial regulations. Among these is the requirement in Ontario (the Highway Traffic Act) that a conversion centre must have on staff a certified mechanic who holds the S6A Propane Fitter's Certificate and that the persons responsible for inspection of

the propane conversion shall also hold the S6R Propane System Inspector's Certificate. The certificates can be obtained by those already holding a motor vehicle mechanic's licence after successful completion of an examination following a course of approved instruction at a local community college or equivalent training on site.

Since equipment developments are rapid, the certification of employees should be followed up by regular on-site refresher courses and by the posting of new information.

5.3. Component Certification

Safety regulations are also in effect which control the materials and methods of construction and the testing required of the components of the propane engine and fuel system. Further regulations aimed at preventing fuel leaks and other incidents specify the way in which these components shall be connected and supported at the vehicle and the distance of tanks from the ground and so forth. Details of the regulations are to be found in Canada Standard CAN 1-B149.2-M80 and related Ontario Regulations (825/82) which are both contained in the publication "Ontario Propane Storage, Handling and Utilization Code."

5.4 The Components and Tests

5.4.1 The Propane Fuel Tanks

The propane fuel tanks are equipped with valves and gauges similar in construction and purpose to those already described for the bulk storage tanks. In the bus, however, (see Figure 7) four separate vessels are manifolded together to form essentially one large storage tank, but only one vessel is accessible from the fuelling door at the side of the bus. This tank alone has a filling valve and liquid contents gauge. The disposition of these and of shutoff valves and shielding of the tank assembly on each tank are shown in Figures 7 and 8 respectively. The fuel tank must be labelled as shown in Figure 6, p.32 and the tank will also bear another stop fill decal which reads:

CAUTION
STOP FILLING WHEN LIQUID
APPEARS AT OUTAGE VALVE.

AVERTISSEMENT
ARRETEZ LE REMPLISSAGE
DES L'APPARITION DU LIQUIDE
A LA SOUPAPE DE JAUGEAGE.

Figure 7

The Bus Fuel Tank System

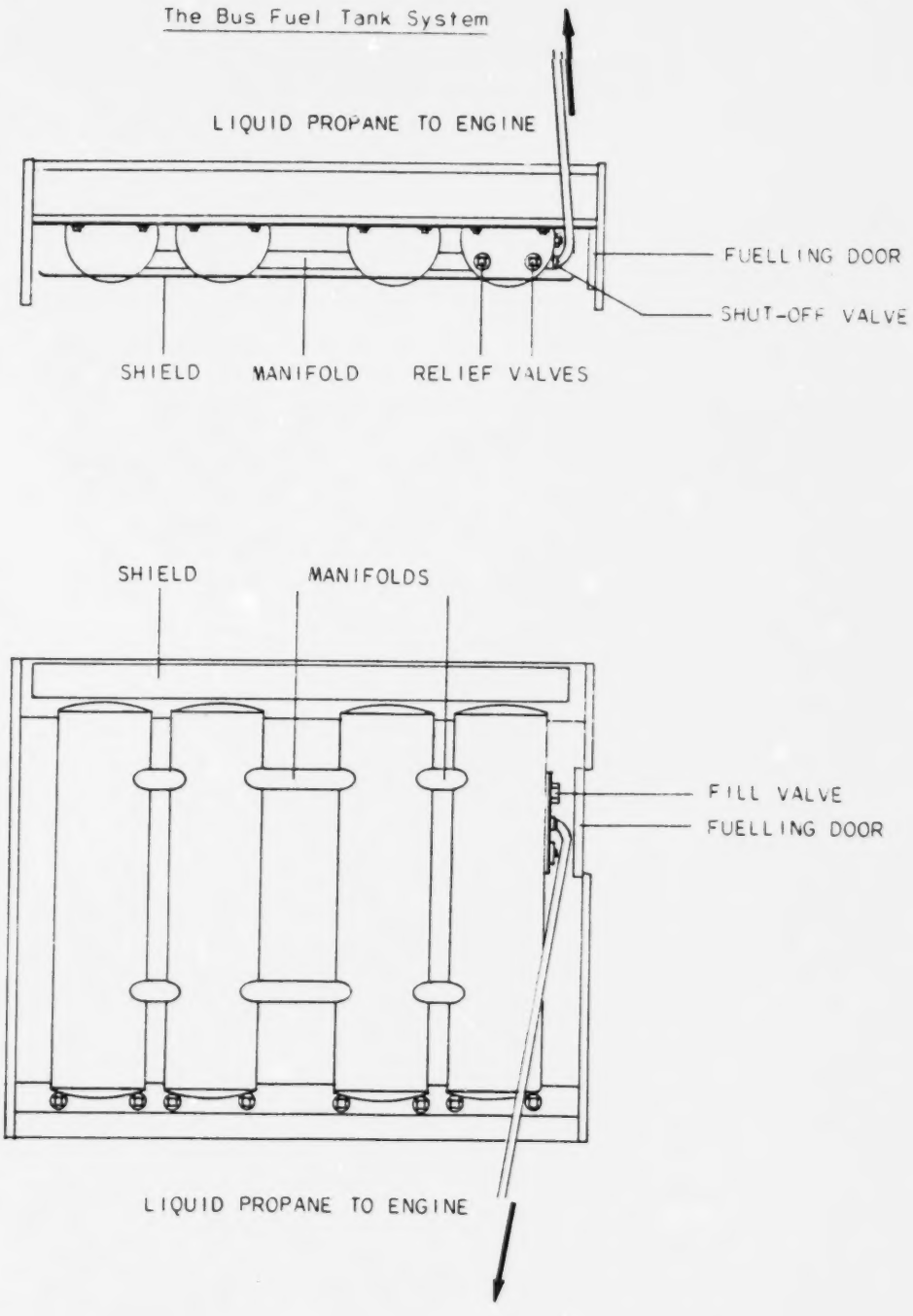
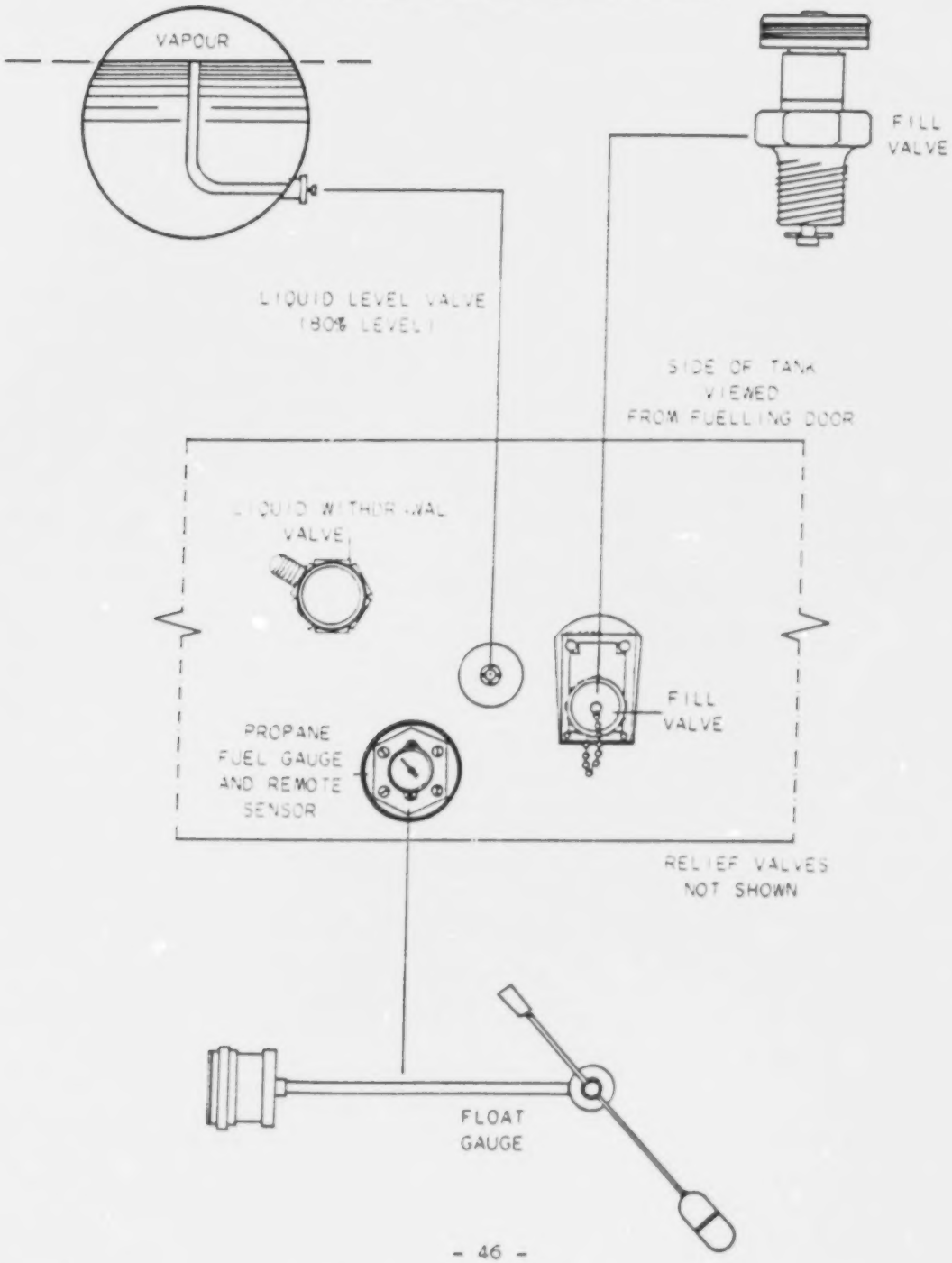


Figure 8

Vehicle Fuel Tank Valves and Gauges



Since the manifolded tank is mounted under the vehicle, it is required to have a design working pressure of 1750kPa (250 psig), which is indicated on the data plate attached permanently to the tank. The tank is located to minimize damage from obstacles that may be encountered en route, such as open manhole covers and rocks. The valves on the tank are shielded to prevent their being sheared off in an accident, which could lead to propane leaks. The tank is located with sufficient clearance from the ground to avoid damage from contact with the pavement when going over curbs or other obstructions. Bumpers are also provided to shield the tanks from rocks, open manhole covers and the effects of collisions.

5.4.2 Valves and Gauges at the Tank

The fuel tank reached from the side of the bus contains:

- a filling connection and fill valve
- a fixed liquid level valve (80% fill)
- a pressure relief valve
- a liquid contents gauge
- a liquid withdrawal valve (to engine via fuel lock and filter).

The filler valve is a one-way valve, short and protected from dirt and ice by a screw-on cap held captive to the connection by a chain and accessed through the fuelling door at the side of the bus.

The fixed liquid level valve (or "spitter valve") is an important safety feature since it indicates when the tank has been filled to 80% of the tank volume. The valve contains a dip tube at the 80% fuel level and is opened manually at the beginning of the filling operations and closed when a visible plume of propane vapour appears at the small orifice in the valve. Inspection of this valve during vehicle conversion and at regular intervals will ensure that:

- the valve is labelled "Stop filling when liquid appears"
- the valve is clear of obstruction and can be operated easily with a gloved hand
- the valve has a discharge which can be seen (tested with fuel outside the garage)
- the valve is leak proof when closed
- the valve is sited not to discharge liquid into an enclosed or prohibited space.

Since the valve has an opening less than 1.4 mm in diameter (by regulation not larger than a #54 drill size) and is closed manually, it is not required to be connected through an excess flow valve.

The relief valve is set to discharge propane to the atmosphere if the working pressure in the tank is exceeded by a certain amount. This spring-loaded valve is situated so that its discharge may be conducted

away from the public, the tank, the engine and exhaust area. Ontario regulations may require the discharge to be directed downward at least 15° from the horizontal. The working parts of the relief valve are contained within the tank for protection. The relief valve has a rain/dust cap fitted which should be in place at all times.

The liquid withdrawal valve is a composite valve so designed that when threaded through the wall of the fuel tank it has a check valve within the tank (excess flow valve) and another exterior to the tank. Liquid propane will not escape, even if the outer part of the valve assembly is sheared off in an accident. Provision is also made to shut off the fuel flow manually by means of a manual shutoff valve in the fuel line.

The liquid contents gauge (or "sight gauge") on the fuel tank shows the approximate contents of the tank and cannot be used in the fuelling process to control overfilling (the 80% fill valve does this). This float gauge is connected to a magnetic gauge which provides (through a remote sensor) a display of the fuel level to the driver.

5.4.3 Hoses and Piping

The propane supply lines carry liquid propane from the fuel storage tank to the filter/fuel lock, then to the converter-regulator where it is vapourized and then the vapour is drawn into the carburetor to be mixed with air before the combustible mixture is drawn into the combustion chambers of the propane engine.

There are strict rules for the materials, assembly and testing of this hose/piping assembly. Ontario Propane Standard No.1/81 provides the complete set of requirements. The preferred practice will include:

- mounting for ease of access for inspection and maintenance (especially joints, connections)
- mounting to minimize the effects of vibration, strain, wear
- protection to minimize corrosion of the tubing and supports
- minimum bending of piping which should be kept short
- minimum clearance of 20 cm. from exhaust system unless shielded
- special precautions must be taken with the hose to provide ease of access and replacement
- use of hydrostatic relief valves between shutoff valves to prevent blow-out or rupture if fuel expands or vapourizes in the line when closed.

5.4.4 Engine Components

The filter fuel lock device and other components in the propane pathway to the engine are factory tested in the installed stated and require only inspection and test at the rebuild point and at subsequent repair and maintenance times. The suppliers' manuals and the

publications of the Ontario Drive Propane Program (such as the 1981 "Switching to Propane: A Guide for Fleet Operators") provide details of these components. The key safety feature is that the propane supply to the vapourizer and carburetor is shut off automatically at the fuel lock valve when the ignition is turned off or when the engine is not running.

5.5 System, Test and Inspection for Safety

5.5.1 Inspections

The inspection of the propane fuel system and components is the responsibility of the maintenance staff assigned who will have the required S6B certification. The inspections of the propane fuel systems will be reported to the Manager, Equipment (Engineering), in Ontario the Ministry of Transportation and Communications MVIS Group (Form 7178): see Appendix.

The inspections include:

1. An initial inspection and vehicle certification for service. This includes leak testing. Upon satisfactory certification a sticker (see Figure 9) will be applied to the front windshield of the bus.
2. Periodic inspection for corrosion, deterioration and minor repairs (major repairs require leak testing and recertification). This is to be at intervals of not more than one year.

5.5.2 The Acceptance Tests

After assembly of the engine and fuel system in the bus and the inspection for labeling and conformity to regulations, there are five major tests to be performed before the vehicle can be put into service:

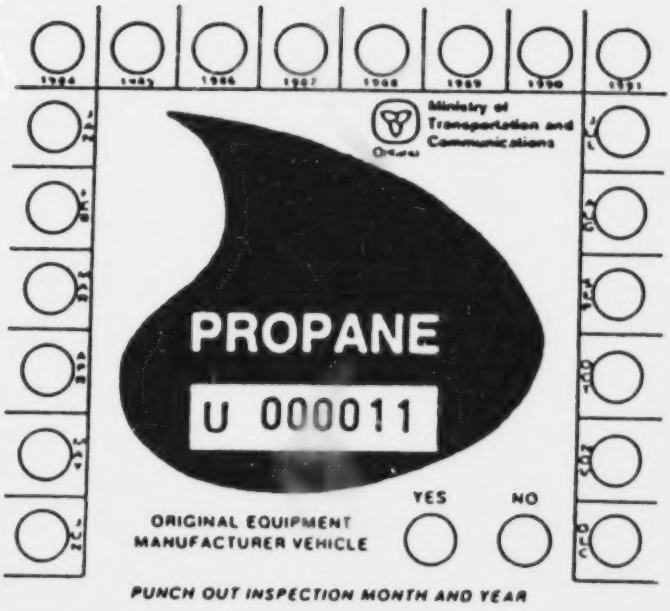
1. Testing of the propane system for leaks and their correction.
2. Testing of the engine and its optimization.
3. Purging of air from the fuel system and the establishment of a propane environment.
4. Testing of the excess flow valve.
5. Vehicle performance tests to show the correct functioning of all components, including the new fuel system.

Some of the tests can be performed in the garage, others which require propane venting are conducted outside at one of the selected fuelling islands.

Leak Testing is performed at the garage to ensure the tightness of the system before propane is admitted. In the preferred leak test pressure is applied throughout the fuel system by the use of inert nitrogen, which step also purges the system of air before propane is admitted.

Figure 9

Certification Sticker



Apply sticker to inside, lower part of front windshield.

Punch out OEM "yes" or "no".

Each sticker will have a different number.

Sticker is blue on white.

In the leak test a detergent water solution or proprietary leak detection solution is used to coat the high pressure lines, connections and fittings. The system is pressurized with nitrogen from a cylinder that is connected to the propane fuel inlet port of the main tank. The tank is pressurized to 70 kPa when leaks are indicated by the appearance of bubbles at the leak site. A mirror is used to check the back sides of the systems. The leaks are corrected and the system cycled by pressurization with nitrogen and draw off of nitrogen by application of a vacuum at the vacuum port of the fuel lock-filter connection.

When the leak testing is complete and air has been displaced and purged the tanks are isolated by closing the fuel inlet valve and the fuel outlet (service) valve on the fuel tank and then the fuel line to the fuel lock-filter assembly is disconnected and replaced by another fuel service line from a small (10kg) portable propane bottle. The small portable propane bottle is placed in the bus and connected via the service line through the back seat service area to the fuel lock-filter of the propane engine. The portable bottle is positioned so as to supply propane liquid when the engine is started up. The engine is started up and the bus driven to the dynamometer test room for engine testing and tune-up.

Engine testing: when the testing and tune-up are complete, the vehicle is driven from the garage to one of the designated fuelling islands where the engine is stopped, the battery disconnected and all sources of ignition are removed before the second purging operation is undertaken.

Propane Purging: with the small tank isolated by closing its shutoff valve, the fuel line from the portable bottle of propane is disconnected from the fuel lock-filter inlet of the engine and reconnected to the fuel inlet valve of the manifolded main tank assembly and inverted so as to supply propane vapour to the tanks. The fuel service valve is connected to a venting hose that can direct propane vapour away to a safe discharge area distant from the bus and fuelling area when propane is vented from the service valve in the purging operation. The manifolded tank assembly is then purged free of nitrogen by propane vapour, the tank being alternately pressurized to 70 kPa pressure with propane vapour and let down to 14 kPa by closing and opening of the manual service line valve. The process is repeated three times and the tank then again pressurized to 70 kPa with propane vapour and with the fuel service valve closed. The propane vapour line from the small bottle is then removed and the in-vehicle fuel system reset for conventional operations by reconnecting the fuel service line from the tank to the fuel inlet of the fuel lock-filter assembly at the engine. With the fuel service valve open, the line to the fuelock is momentarily 'cracked' to fill the line with propane vapour and then reconnected. The system is now filled with propane vapour and suitable for its first fuelling with liquid propane at the fuelling island. When the propane vapours have cleared after the filling, the battery is

reconnected and the bus is ready for the test of the excess flow valve.

Test of Excess Flow Valve simulates a condition where the fuel line is severed and the functioning excess flow valve (which is built into the valve at the fuel outlet) should immediately shut off the flow of liquid propane. The simulation is conducted as follows. The engine is started up and the service valve at the fuel tank is shut off manually: the engine runs until the fuel in the service line is consumed and then stops. After a pause the manual valve at the fuel service outlet is quickly opened. (If not quickly, then the valve will be set to deliver fuel). If the excess flow valve is functional, then no significant flow of fuel to the service line will have occurred. An attempt is then made to start up the engine: it should not run. If it does not run, the excess flow valve is satisfactory and the manual service valve at the storage tank should be opened slowly and left in the open condition. The bus can be driven off for the completion of the acceptance tests. If the engine does run in the excess flow valve test, the test should be repeated. If the same result is obtained, the valve should be replaced.

Note that this valve should be opened fully or closed tightly - a half-opened valve can leak.

Bus Operability: the final segment of the acceptance test involves testing the bus for operability and has no special safety test requirement that is related to the use of propane.

A written report on the CERTIFICATION TEST should be prepared with copies maintained in the Equipment Department and the Security office.

5.5.3 Periodic Inspections

There are two types of routine inspection that will ensure maximum safety of the propane buses:

1. Fuel System Inspection: the bus should be routinely checked at intervals of six weeks to determine that there are no leaks in the fuel system. This inspection involves:

- Closing the fuel service valve and running the engine until it stops. Repeat several times. This ensures that the shutoff valve is operating.
- Tracing the fuel lines (hoses, piping connections) with a portable leak detector. This will detect not only leaks at the joints, but also a porous condition which could develop in hoses. (A suitable detector is the battery-operated hand-held CG Tracer Model 501 available from the Leak-Tec Division of American Gas and Chemical Ltd. which provides an audible alarm and a visual meter reading).

- A visual inspection of the fuel tank and its supports to ensure that no damage or corrosion have occurred.
- A visual inspection of the fuel filler valve and screw-on cap to ensure that they have not been damaged.
- An inspection of the fire extinguisher carried in the vehicle.

2. Annual Inspections. These will repeat many of the inspections and tests required to certify a newly-converted vehicle. The inspection in addition to those normally provided for buses, will include the following aimed at maintaining safety in the propane system:

Fuel Tank

- A visual inspection of the tank and manifolds for damage, corrosion, protective coating condition.
- Inspection of the manufacturer's label and labelling on all valves.
- Inspection of the gauges, valves, filler cap for damage, working condition.
- An inspection of the shields on each tank for damage.

Lines and Fittings

- A visual inspection of the fuel line, fill line, fixed liquid level valve and gauge, and the relief valve and piping for damage, corrosion, or wear.
- An inspection of the mountings of the fuel lines and any other service and hydrostatic valves in the fuel lines.
- Visual inspection of electric cable and connections in the fuel path.

Engine Components

- Check of fuel filter for cleanliness.
- Visual inspection of the fuel lock-filter, vapourizer, carburetor, for damage.

Fire Extinguisher

- Inspection of fire extinguishers on the bus.

Testing of Vehicle

- A leak check with a portable leak detector of the fuel tanks, fill-up, hoses, valves and components.

- Test of the excess flow valve at the fuel tank service valve as for the acceptance test.

In addition to the routine inspections, inspection is required upon completion of any repair to the fuel line or engine. Where repairs are conducted, the repaired or replaced equipment shall be inspected and in compliance with the original vehicle certification process. In addition, the inspection for safety after a repair shall include the items specified for the 6 week inspection. Periodic inspections and inspection after repairs should be recorded in writing and a copy of the INSPECTION REPORTS maintained by the Equipment Department.

6. GARAGING AND REPAIR

6.1 General Precautions

The garaging and repair of propane-fuelled buses will require additional safety measures to be incorporated, compared to the conditions which can be used in an all-diesel fuel garage. The new measures involve the addition of some new safety equipment in areas where propane leaks from the buses might accumulate in the buildings, and new rules and regulations for employees working in these areas.

The changes are largely directed toward:

- Scrutiny of refuelling operations to ensure that over-filled vehicles are not parked in the garage.
- Increasing ventilation in areas where propane-fuelled buses are parked, maintained and repaired, and eliminating recycled air to warm working areas in winter.
- Eliminating the possibility that the heavier-than-air propane vapours accumulate in pits, manholes, drains or other depressions below grade in the garage.
- Increasing the safety standards of electrical equipment in use in areas where propane vapour is expected.
- the installation of propane detectors which will provide audible and visual warning of the presence of propane concentrations above a safe level. The alarm systems will be activated whenever propane concentration in the air reaches one tenth of that required to support combustion.

Even at higher concentrations an ignition source (such as a spark, an arc from a welder's torch, or an open flame) is required to start a fire: a substantial volume of propane must also be available to sustain the fire once started.

The specific safety measures described below for the garage and repair areas are based upon the experience of bus properties (such as Chicago Transit and Vienna Transit) and upon Canada Standard CAN 1-B149.2-M80. For the bus garage the strict safety measures recommended herein recognize the large volume of propane carried in a bus and are therefore based not only upon those required for garaging and repairing propane-fuelled vehicles, but also draw upon many features of the very strict standards set in CAN 1-B149.2-M80 for the garaging and repairing of propane tankers.

6.2 Precautions for Parking Vehicles

A NO SMOKING sign shall be displayed at each entrance to the

garage and within the garage. In addition, signs giving instructions in the event of a leak or fire will be displayed within the garage.

- The bus must not be parked in the garage when the fuel tank has been filled beyond the 80% fill level or when a leak in the fuel system has been observed.
- In the event of damage to a bus, permission must be obtained from the garage supervisor before the bus is parked in the garage.
- The bus will not be parked within 5 metres of sources of heat, open flames or similar sources of ignition.
- The bus will not be parked below grade.
- No smoking is permitted in the propane bus garage.
- Each garage within the garage complex is to be fitted with propane gas detection equipment connected to a visible and audible alarm system.
- Each bus in the garage and each garage area shall be equipped with dry-type fire extinguishers.
- For normal parking the fuel system is secure without closing of the manual shutoff valves at the fuel tank. When the bus is parked in an exceptional place, such as within 5 metres of an unventilated open pit, or left unattended for an extended period in an public area, the manual shutoff valve at the tank will be closed.
- Should propane escape from a vehicle parked in the garage (it may often be detected by smell or by the alarm system), the manual shutoff valves on the vehicle fuel tank system must be closed promptly and the incident reported to the garage supervisor. Depending on the extent of the leak, the supervisor will determine whether to alert security or open the garage doors to speed propane dispersal.

6.3 Repair and Maintenance

6.3.1 Buses

Repair and maintenance to buses shall only be performed in the specially designated area of the repair and maintenance department and by staff with the required certification (S6A in Ontario) and in-house training, which includes instruction in fire control.

6.3.2 Building and Equipment Requirements

The repair and maintenance area for propane is segregated from the diesel maintenance and repair section by a wall not lower than 2 metres in height, within which special ventilation, propane sensing and fire prevention equipment are used.

Entrance to the area from within the garage and from the outside bus entry is marked by signs which bear the messages:

"NO SMOKING"
"DANGER OF FIRE NO SMOKING NO OPEN FLAMES"
"ENTRY PROHIBITED TO UNAUTHORIZED PERSONNEL".

Ventilation: the propane maintenance and repair area must be ventilated by a system which provides an external source of fresh air (not recirculated air). The inlet to the ventilation area will be through an intake vent segregated from other inlets and is checked to ensure that no flammable vapour or liquids can be drawn in.

- The ventilation system will vent to the outside via the roof with the vented air directed away from the vehicle storage and fuelling area.
- The system is to be constructed of non-flammable materials.
- The ventilation system should be able to provide an air change rate of ten volumes of air per minute (to dispel propane spills).
- Each pit shall be fitted with a separate exhaust system providing 20 air volume changes per minute when activated, and the ducting from the ventilation system of the pit shall be connected to the main venting system.
- All ventilation systems must be fitted with gas-tight seals.
- The ventilation systems must be inspected at two monthly intervals.
- In an emergency the ventilation in the maintenance area can be increased by opening the entrance doors.

Gas Detection/Alarm Systems: each pit shall be equipped with a gas detector connected to the multiple detector monitoring and alarm system. The detector system in each will be inspected every two months and deficiencies corrected before further repair work in the area is permitted. Gas detection sensors shall be installed at other points in the maintenance and repair area close to floor level (where dense propane vapours might accumulate). These too will be tied into the central monitoring and alarm system. A gas leak (which trips the alarm system when the propane concentration exceeds one tenth of that required to support combustion) will activate a visual and audible alarm system within the maintenance area and at the Security Office. The suitable multi-detector gas detection and alarm systems are available from many suppliers; a typical unit is the AMC 1014 4 sensor system available from the Armstrong Monitoring Corporation, which system may also be supplied with a chart recorder. The sensing alarm systems will be set to continuously monitor each critical area in the propane repair and maintenance area, 24 hours per day, 7 days per week.

Fire and Other Safety Equipment:

- A fire alarm shall be installed next to the master switch of the ventilation system and clearly marked.
- Portable solid-type chemical fire extinguishers shall be provided at points designated by security and the fire department and

regularly inspected (every two months).

- Repair and maintenance personnel will wear protective gloves and goggles when a repair to the fuel system could lead to contact with the liquid fuel.

Electrical Equipment: all the electrical equipment fixtures and cables located within the "propane-safe" area and not more than 2 metres from the ground level in the area shall be designed to be fire and explosion proof in conformity with the Provincial Electrical Code or the CSA C22.1 "Canadian Electrical Code" for Class 1, Division 11, Group D hazardous substances. Conformity at the roof and with fixtures at greater than 2 metres height is not required (due to the density of propane and its inability to rise), except within the ventilation ducts. (In a totally new facility for propane repair, it could be convenient to install explosion-proof fixtures throughout the repair and maintenance zone).

6.3.3 Repair and Maintenance Operations

- Normal maintenance and repair to the vehicle and engine which do not involve welding or exposure to ignition sources, will be undertaken with the fuel tank closed off at the manual shutoff valve of the fuel service line. The manual shutoff is maintained until it is required to operate the engine for test or to move the repaired bus to other locations.
- Before repairs of any kind are undertaken, the level of fuel in the tank must be checked to ensure that the vehicle is not over-fuelled to avoid a vent-off from the relief valve during repair.

Preferably repairs will be undertaken with buses which have not just been refuelled. For all but repairs involving ignition sources, 50% or less fuel with the fuel tank manual shutoff valve is desirable. A low level of fuel in the propane tank during repair is especially desirable when the ambient temperature in the repair shop exceeds 38°C (100°F).

Where repairs are to include those to the fuel tank or fuel lines, wherever leaks have been detected, and wherever there is welding and similar exposure to sources of ignition, the vehicle tanks should be emptied of propane and purged with nitrogen before the work is undertaken. No welding is permitted on the tank itself - only on brackets. Under these circumstances, the vehicle tank will be vented free of propane outside the building at the special section of the fuelling islands which has the propane disposal hose in place capable of discharging propane vapour at a remote, safe area 25 metres or more removed from the building, fuelling island, bulk storage area, and all sources of ignition. At this location, with the manual shutoff valve first closed, the fuel service line within the vehicle will be disconnected and the tank outlet connected to the disposal line when the

service valve will be slowly opened, and the propane contents of the tank slowly vented. The tanks in the vehicle will then be purged with nitrogen (as described in the acceptance tests of Section 5). The fuel for subsequent movement of the vehicle to the repair area is to be provided by a small bottle of propane which can be removed from the vehicle while repairs are undertaken, as described in Section 5. Where simple replacement of a fuel hose section is required, the supervisor may waive the fuel discharge requirement by exception to the normal practice.

- Buses will be tested for fuel leaks with the portable leak detector before repairs are undertaken.
- After completion of repairs to the fuel system, the conditions of the acceptance test will be followed by tank purging, refuelling and testing of the emergency shutoff valve, then refuelling outside the building at the fuelling island.

In the event that a propane fuel tank is scrapped, it must not be assumed that the tank is empty, even though the fuel gauge indicates zero fuel. There may be combustible propane vapour in the tank which must be purged with nitrogen before disposal of the tank or its shipment back to the manufacturer for inspection and disposal. The propane tank must be removed from any bus and purged before the bus is scrapped.

6.3.4 Emergency Conditions

Propane Leaks: in the event of a leak of propane being detected while a vehicle is in the parking area of the garage:

- All vehicle engines will be stopped with the ignition keys removed and personnel not required to service the incident will be evacuated and the Security Office and the repair shop alerted.
- All other potential sources of ignition in the building will be removed.
- Fire extinguishers will be readied and the source of the leak pin-pointed. The manual shutoff valve at the fuel tank on the leaking vehicle will be shut off and the garage doors opened to ventilate the area.
- Water sprays will be used to assist in the dispersal of the propane vapour, to prevent ignition and cool the tank of the leaking vehicle.
- The supervisor will check the dispersal of the propane vapour with the hand-held leak detector and when no source is further detected, will advise of the re-start of operations.
- Buses will be removed from the parking garage to isolate the vehicle in need of repair, which will then be assigned to the repair and maintenance staff for testing and repair or towed from the garage to a safe area to await later repair.
- A REPORT on the incident will be provided to the Manager of

Operations, the Chief of Security and the Manager of the Equipment Department.

Leaks of propane encountered in the repair shop will be treated in a similar fashion:

- An alert will be provided to the Security Office.
- Ignition sources will be shut off, fire extinguishers readied and a check made that the manual shutoff valve on the fuel tank of the leaking vehicle is closed.
- All personnel not required to contain the incident will be evacuated from the area.
- A water spray and ventilation system will be used to disperse the leaked propane.
- The doors of the repair shop will be opened also if possible to speed the vapour dispersal.
- The supervisor will check the area for leaks until no source is located and give the instruction to resume work.
- A REPORT on the incident will be prepared and submitted to the Manager of Operations, the Chief of Security and the Manager of the Equipment Department.

Fire: the major concern with a fire at a propane garage - whether it originates with a propane leak or other conventional source unrelated to propane - is that the fire will take hold in the bus interior or tires to such an extent that the temperature in the propane fuel tank could rise and propane then vented through the relief valve, thereby sustaining or spreading the fire. This ignition of the fuel source also is the major problem with gasoline and diesel-fuelled vehicles and indeed, the thin walled tanks containing these conventional fuels are more vulnerable to crash and fire damage than propane tanks.

Where the fire is occasioned by a propane leak, it is important to identify and shut off the source and not just to extinguish the flame. Collection of vapour and its re-ignition - perhaps explosive - present a greater danger than the fire itself.

The emergency plan proposed for the containment of fire provides that:

1. The fire alarm be given which will alert all personnel at the site, the Security Office, the local fire fighting group and the Fire Department.
2. The Security Office will determine whether the fire site is in a propane-vulnerable area and whether a general evacuation of non-essential personnel from the site is warranted.
3. In the event that the fire is NOT in the propane zone, it shall be fought in the customary manner, while all precautions are taken within the propane-sensitive area to:

- eliminate source of ignition
- stop propane flow to vehicles refuelling
- move buses from the garage and garage site
- if the fire is severe, to begin water cooling of fuel storage tanks and evacuation of all non-essential personnel from the site.

4. In the event that the fire is in the propane zone:

- the Security Officer will instruct non-essential personnel to leave the zone on foot
- buses not in the immediate vicinity of the fire will be removed to a distant parking location 300 metres or more from the building
- the remaining ignition sources in the building will be closed off
- the source(s) of leaking propane, if any, will be secured by closing off vehicle fuel tanks manually at the service valve
- after the source of propane has been closed, the fire will be extinguished by use of fire extinguishers of the approved solid type, and water hoses used to extinguish the fire, disperse vapour and to cool any propane tanks in buses left in the vicinity of the fire
- the fire-fighting task will be handed over to the Fire Department when they arrive on the scene, with OC Transco-trained staff conducting tasks assigned to them by the Fire Chief of the site
- when conditions permit and the fire is extinguished and danger passed, propane sensing will be undertaken and when propane vapours are not present, the Fire Chief and the on-site Chief of Security, in conjunction with the General Manager, will provide authorization to resume work in the building
- when conditions permit, the supervisor of the affected area will prepare a FIRE REPORT, copies of which will be filed with the General Manager, Office of Security, the Equipment Department, the Fire Department and the Ontario Ministry of Consumer and Corporate Relations Safety Branch.

7. OPERATING PROPANE BUSES

7.1 Operation of the Bus

The propane bus is operated in exactly the same way as its diesel equivalent and has been designed to provide a range, power, acceleration and brakability identical to those of the conventional diesel bus. The driver may, in addition, enjoy the low level of noise and vibration and the smooth pull- away that propane confers: riders may enjoy these and the absence of smoke and odours that unfortunately characterize the diesel bus.

7.2 The Safety of Propane Vehicles

Analysis of the safety record of propane-fuelled vehicles shows that they have an outstanding record for safety: the record for buses operated in major cities, such as Chicago and Vienna, is even more outstanding.

Many of the safety-related problems that have been reported for propane vehicles refer to problems that could not arise with buses, and particularly with the buses using specially-designed pre-tested factory manufactured heavy-duty propane engines and prefabricated pre-tested fuel storage tanks. Many of the problems previously reported were special to gasoline-engined systems which were converted to propane outside the factory with inadequate standards of assembly and inspection.

The possibility of damage to the tank and pipelines in the bus is reduced by the shields and the bumper device built into the tank design.

The Road Research Laboratory in Holland (TNO, Delft) and Volvo have conducted many crash tests of propane tanks of the configuration and valved like those in the OC Transpo buses. Even high speed crashes, including those with a railway locomotive, failed to puncture the propane tank or cause the emergency shutoff valves in the tanks to release fuel. In other tests, TNO set a diesel and a propane bus on fire to test the fuel systems, the relative flammability and danger of the two fuels. The diesel bus in this test was the faster to burn and emitted a great deal of smoke which could inhibit fire-fighting. The propane vehicle blew off a jet of propane from time to time as the tank relief valve operated to vent the pressure in the tank. This showed that it is important that the jet be directed away from firefighters by a properly-directed vent pipe.

While the design and manufacture of the buses is specifically aimed at minimizing the chances for fire, accident statistics show that fires do occur occasionally on conventional diesel-powered buses.

The procedures to be followed in the event of a collision or fire are next examined.

7.3 Accident Procedure

Should the bus be involved in an accident, the driver should shut off the ignition and then close the manual shutoff valve of the fuel delivery outlet of the fuel tank before taking further action.

In the Event of a Leak Without Fire: if a leak of propane can be smelled or heard:

- The driver will evacuate the bus, asking passengers to disperse 500 metres or more upwind of the bus and to keep vehicles away from the bus.
- The driver will not make radio contact from the bus nor activate any possible source of ignition on the bus.
- The driver should request a passenger or passer-by to telephone Security at the garage to inform them of the accident. The driver will not leave the vicinity of the vehicle until relieved by OC Transpo personnel, nor should he re-enter the bus.

In the Event of a Fire in the Bus:

- The driver will follow the above procedure, but also attempt to extinguish the fire with the solid-type fire extinguisher, if the fire is in the bus and can be fought.
- Under NO circumstances should the fire be fought if a propane leak is suspected until the manual shutoff valve at the fuel tank is closed.
- If the fire persists, the driver will remain in the vicinity of the bus to warn passers-by, to keep other vehicles from approaching the bus, and to request that the Fire Department be promptly dispatched.
- When a water hose is available from the arrival of the Fire Department or other sources, it should be directed at the fire, the propane source, and at the fuel tank to keep it cool (to prevent venting at the relief valve).
- Each accident will be reported to the Chief of Securityin an INCIDENT REPORT. All enquiries regarding the incident will be referred to the Chief of Security for his answer or referral to the General Manager.

APPENDIX

Ontario

Ministry of Transportation and Communications

MVIS Group
1201 Wilson Ave
Downsview, Ontario
M3M 1J8

Propane Fuel System Inspection Report

Instructions: • Complete and mail all inspection reports, whether the vehicle is rejected or accepted, within 30 days to M.V.I.S. Group, 1201 Wilson Ave., Downsview, Ontario M3M 1J8.
• Suggest vehicle owner to record the sticker serial number and place it on the inside surface of the glove compartment door.

Vehicle Owner

Surname | Given Name(s) | Initial

Address: Street Number, Name, P.O. Box No., RR. No. or Lot, Con. & Twp. | Apt. No.

City, Town or Village | Postal Code

Vehicle

☐ Propane Only ☐ Dual Fuel

Vehicle Identification Number | Plate No.

Make | Model | Year | Odometer Reading

Tank | Manufacturer | Serial Number | Date Manufactured Month, Year

1.

2.

☐ Data not visible ☐ Equipped with automatic stop fill valve *

Location: ☐ Inside ☐ Outside — Fill Location ☐ On tank ☐ Remote

Fuel Lines
☐ Steel
☐ Type III hose — Year Installed
☐ Type II Hose ☐ Green ☐ Black

Components | Make | Model
Fuel Lock
Vaporizer
Mixer

Inspection

Inspection Date: Day, Month, Year

Conversion Date: Day, Month, Year

☐ Initial Inspection

Name of Converter

Contractor's Registration No. | Installing Fitter's 54A or 58B Certificate No.

Date Manufactured: Month, Year

☐ Resale ☐ Original Equipment Manufacturer

Results

☐ Rejected ☐ Repaired ☐ Accepted

Inspection Sticker Number Issued: U

Defect Report & Check List

	Defect Found	Description	Defect Corrected
1.0		Tank	
1.1		Valves – Fittings – Gauges	
1.2		Damage	
1.3		Ground clearance	
1.4		Location	
1.5		Mounting – Attachment	
1.6		Corrosion	
1.7		Compartment Vent – Seal	
1.8		Canadian registration no.	
1.9		Design Pressure	
1.10			
1.11			
2.0		Lines and Fittings	
2.1		Fuel Line	
2.2		Fill Line	
2.3		Fixed liquid level line	
2.4		Relief valve lines	
2.5		Filler cap	
2.6		Fittings	
2.7		Installation	
2.8		Mounting – Attachment	
2.9		Corrosion – Damage	
2.10			
2.11			
2.12			
3.0		Equipment	
3.1		Fuel filter	
3.2		Fuel lock-off	
3.3		Vaporizer	
3.4		Mixer	
3.5		Hydrostatic relief	
3.6		Back check valves	
3.7		Remote fill	
3.8		Gasoline lock-off	
3.9			
3.10			
4.0		Testing	
4.1		Tank leakage	
4.2		Fitting leakage	
4.3		Fuel lines leakage	
4.4		Components leakage	
4.5		Excess flow valve	
4.6		VAC/OIL fuel lock-off	
4.7			

We hereby submit the information contained herein in accordance with the inspection requirement for a propane fuelled vehicle made under the Highway Traffic Act.

Name of Inspection Station | Motor Vehicle Inspection Station Licence Number

Name of Registered Mechanic | Mechanic's 58B Certificate Number

7178

INSPECTION CRITERIA FOR L.P.G. CONVERSION (1)

ITEM (& INSPECTION METHOD)		REQUIREMENTS
1.0	L.P.G. TANK	
1.1	Labelling	
1.1.1	Approval	- Canadian Registration Number
1.1.2	Name Plate	- Name plate bearing the following information: - Canadian Registration Number (C.R.N.) - Manufacturer's name and serial number - Marked for L.P.G. - Capacity - lb. or water capacity in U.S. Water Gallons. - Design pressure - Date of manufacture.
1.1.3	Valve Identification	- Attached metal plates or labels identifying: - Liquid opening (liquid line outlet) - Vapour opening - Fill valve opening (liquid fill inlet)
1.2.1	Working Pressure	
1.2.1.1.	Open area	- Not less than 250 P.S.I.G. (1750 KPA)
1.2.1.2	Enclosed area	- Not less than 312 P.S.I.G. (2150 KPA)
1.3	Tank Requirement	
1.3.1	Liquid Fuel Line Outlet	
1.3.1.1	Manual Valve (Liquid Service Valve)	- Installed in tank - U.L., U.L.C., C.S.A., C.G.A. approval - Approval stamp visible - Brass

INSPECTION CRITERIA FOR L.P.G. CONVERSION (2)

ITEM (& INSPECTION METHOD)		REQUIREMENTS
1.3.2	DIRECT FILL	
	Liquid Fill Inlet	
1.3.2.1	Double back check valve	- Installed in liquid fill valve - U.L., U.L.C., C.S.A. or C.G.A. approval - Approval stamp visible - Brass
1.3.2.2	Liquid Fill Valve	- Installed in the tank - U.L., U.L.C., C.S.A. or C.G.A. approval - Approval Stamp visible - Brass or steel - Equipped with cap.
1.3.3	Fixed Liquid Level Outlet	
1.3.3.1	Fixed Liquid Level Gauge	- Installed in tank - U.L., U.L.C., C.S.A., or C.G.A. approval - Approval stamp visible? - Orifice no larger than #54 drill size - Attached label: "Stop filling when liquid appears"
1.3.4	Tank Relief Outlet	
1.3.4.1	Tank Relief Valve	- Installed in tank - U.L., U.L.C., C.S.A. or C.G.A. approval - Approval stamp visible - Manufacturer's name and number - Discharge rate in cubic feet per minute - Discharge pressure same as tank working pressure - Brass - Must vent to outside and down at an angle of at least 15^{o} from horizontal - No equipment or shut-off valves between tank and relief-valve opening.

INSPECTION CRITERIA FOR L.P.G. CONVERSION (3)

ITEM (& INSPECTION METHOD)		REQUIREMENTS
1.3.5	Content Measuring Outlet	
1.3.5.1	Magnetic Float Gauge	- Installed in tank - U.L., U.L.C., C.S.A. or C.G.A. approval - Approval stamp visible
1.3.5.2	Remote Sensing Device	- Installed as option - U.L., U.L.C., C.S.A. or C.G.A. approval - Approval stamp visible.
	REMOTE FILL	
	Liquid Fill Inlet	
	Double Back check valve	- Installed at fill point - U.L., U.L.C., C.S.A. or C.G.A. approval - Approval stamp visible - Brass
	Fixed Liquid Level Outlet	
	Fixed Liquid Level Gauge Adapter	- Installed in tank - No approval required - Brass

RECOMMENDED REFERENCE MATERIAL

Ontario Propane, Storage, Handling and Utilization Code, 1983, Canadian Gas Association, 55 Scarsdale Road, Don Mills, Ontario M3B 2R3

Switching to Propane: A Guide for Fleet Operators, Ministry of Transportation and Communications, 1201 Wilson Avenue, Downsview, Ontario M3M 1J8

Storage and Handling of Liquified Petroleum Gases, 1983, National Fire Proection Association Inc., Batterymarch Park, Quincy, MA. 02269 U.S.A.

LP-Gas Operations and Safety, National LP-Gas Association, 1301 W 22nd Street, Oak Brook, Illinois 60521, U.S.A.

LP-Gas Tanks, Cylinders and Equipment, National LP-Gas Association

LP-Gas Safety Handbook, National LP-Gas Association